WEEKLY BULLETIN

OF THE

Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, JANUARY, 1918. No. 1

EDITORIAL NOTES.

Supplementing our usual monthly report, we give, this month, a reprint of a recent lecture given by Dr. Jaggar, Director of the Hawaiian Volcano Observatory at Kilauea. This lecture has attracted a great deal of attention, and it is our hope, in following issues, to issue reprints of other interesting addresses recently delivered by him.

EDITOR.

January 5, 1918.

During the week ending January 4, 1918, the Halemaumau lava column rose seventeen feet and the great central crags in the pit almost as much, so that at the end of the week more than 30 feet of the crags was exposed to view across the edge of the pit as seen from Volcano House. The rapid rising is closely comparable to what happened in the first weeks of 1917 and may be expected to come to an end soon and be followed by subsidence before the March equinox. The great black crags jutting up above Halemaumau produce very much the same effect as in January, 1917. The history of the year just ended is quite accordant with what would be expected if one imagines the Mauna Loa column, after its discharge of 1916, to have risen in the Kilauea pit close to its brim and there maintained an equilibrium except for the effects of earth warpings attributable to tidal stresses. Thus we had rising in the 1916-17 winter, sinking in the early spring, rising in the early summer, a lower level thereafter and pronounced rising again for the 1917-18 winter. In October, 1917, there was some sort of a subterranean crisis following the equinox whereby the ground exhibited astonishing tiltings and there were local earthquakes. Thereafter with the rising lava these exceptional movements wholly ceased and local earthquakes have recently been at a minimum. The great earthquakes which wrecked the city of Guatemala on Saturday, December 29, were clearly recorded on the seismographs of the Whitney Laboratory.

On the morning of Saturday, December 29, the lava lake rose to the level of the inner bench and built spatter domes on both sides of the southeast cove, at the east gulch, the east cove and the central cove. The inner bench was widened to a maximum of 20 feet at the point protruding from the southeast crag and against the east island at the east cove. Elsewhere this bench was from five to ten feet wide. At the east gulch two inner benches were built, respectively six and fifteen feet above the lake, the upper one fuming and sulphur-stained. At 2 p. m. the lake had subsided five feet and was actively fountaining in the southeast cove. At 3 p. m. there was vigorous fountaining in the southwest arm and southwest cove. Looking from the south station it was evident that the south face of the central crag mass was scaling away rapidly as it rose with overhang to the south. From the southwest station it became evident that this rising of the western extension of the central crag mass was again shutting off the southwest arm by developing two bridges of crust, leaving the southwest cove an isolated pond. At 4 p. m. the streaming was to the southeast and north, cracking and foundering of the crusts were going on and there was much splashing in the grottoes with rumbling noises, especially on the west side of the southeast cove. There was much marginal overhang due to tem-

WEEKLY BULLETIN
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Hawaiian Volcano Observatory

Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

porary subsidence. The inner bench was about six feet below the rampart bounding the south valley at the southeast cove. Occasional migratory central fountains would form and most of the lake was covered with crusts of medium thickness separated by bright lines. Glowing orifices were seen above the shore cones at the east gulch and west of the southeast cove. Fumes in general were rather dense. At 5 p. m. a line of traveling fountains formed from the center of the southeast arm to the shore of the southeast crag and migrated eastward. This patch was followed in its progress by more rapid surface streaming from the channel eastward. The central fountains in general exhibited high gas pressure and spraying. A group of them in the middle region were in continuous effervescence. At 5:15 p. m. rising was resumed with much hissing from under border crusts.

Measurement on December 29 made the depression of the lake 78 feet below the southeast rim and the elevation of the east summit of the central crag 7 feet above the level of the rim of the pit, while the summit of the east island stood 2 feet above the rim level. These results showed that in eight days the lake had risen 14 feet, while the central crag was unchanged and the east island crag had risen only 2 feet. From this time on, however, the crags rose rapidly.

On December 30 at 5 p. m. the lake was about 10 feet below the inner bench at the southeast point. There were quiet spells followed by occasional breakings up of the crust. At first there was a rim of overhang two to three feet above the lake with glow and hanging stalactites, but after 6 p. m. this was filled by the rising fluid. Above the lake at the east gulch a glowing crack emitted flames. Central fountains broke out in the middle region and in the southeast arm, and overwhelmed the crust slowly eastward. At the northeastern corner of the southwest cove a glowing cavern led under the central valley. Fragments of the southeastern bench occasionally collapsed. Only three benches now showed in the profile of the southeast crag. There was glow from the north rampart and the fumes in general were heavy.

At 11 a. m. on Monday, December 31, 1917, the lake was higher, the fumes were much thinner, there were central fountains and the crusts were thinner with more rapid streaming. At 4:30 p. m. pronounced rising was in evidence with spatter building and much Pele's hair floating up with the puffing gases at the border grottoes. There were five or six of these, the streaming to the southeast was slow, a large dome had been built at the east cove and there was a large glowing opening at the east gulch. Central fountains were continuous. The southwest pond was now completely shut off and itself crusted over. Twenty feet to the southeast of it on the floor, above the line of the south tunnel, there was a blowing and spurting aperture, noisily building a cone. During a break-up of the pond crust with violent escape of gas and border fountains, it was evident that the gas pressure beneath was relieved and the tunnel vent ceased puffing. During the break-up the streaming was rapid from the bridge of crust on the southwest channel side eastward across the pond, and at the same time there was inrush under this bridge on the lake side, showing that there was still an open arch beneath. As soon as the crust reformed the tunnel vent resumed puffing, the crust on the pond heaving in sympathy. The west cone appeared hot but was not obviously glowing or hissing. A sulphur patch back from the high rim of Halemaumau south-southwest, which a few months ago had been fresh, was now dead and white again.

A spatter dome was building on the west side of the southeast cove. The dome at the east gulch was spurting.

At 5:30 p. m. the southeast arm and central region were crusted over, but there was open streaming from a point opposite the east gulch toward the east and to the inner end of the southeast cove. There was also a surface stream into the central cove. The lake was now two feet below the inner bench.

On January 1, 1918, at 7:30 p. m., the lake appeared about 10 feet below the inner bench, mostly crusted over, with some activity in the north arm and border fountains at the east gulch and southeast cove. No rock falls were heard.

The crags, by measurement from the Observatory, began their pronounced rising December 31 and increased their rate of rising from January 2 to January 4, the east island gaining on the central crag.

On January 3 at 10:30 a. m. the effect of the rising movement of the bench magma was inspected on the inner northeast floor where a most astonishing change of slope was revealed. The upward push of the middle portion of the stiff lava column which forms the lake bottom had lifted the east, northeast and northwest ledges bodily so as to incline them towards the peripheral wall of Halemaumau at angles near 40 degrees. The east ledge was now higher than the southeast shelf. This restores conditions similar to May of 1917. The crevasses northeast have largely closed and indeed pressure ridges have in part replaced them. The recently formed floor margin of the north cove has risen and been crushed between the rising crags east and west of it. On this day the inner bench was four feet high east and southeast, two feet high at the southwest pond and northwest cove and one foot high towards the northeast. The northeast cove valley was floored with fresh lava and the northwest cove was a narrow indentation in a wide floor area. The crusted southwest pond was heaving and the tunnel vent to the southeast of it was hissing continuously and harshly from a network of openings which glowed, flamed and showed sulphur stain.

That the crags were in motion was shown by the fall of rocks from time to time, especially towards the northeast and east. The central crag had lost its high east turret and become a jagged straight-topped ridge.

The lake was rising and crusted over with noisy central fountains near the west base of the east island crag mass. There were occasional heavy bombardments at the coves, especially at the north cove. Occasionally general breaking-up of the crust took place, there were blowing grotto fountains on the west side of the southeast cove and sometimes at the east cove and east gulch. There were spatter domes at the east, northwest, central and north cove. Streaming appeared to be outward from the northwest and southwest coves.

On Friday, January 4, the rising reached a culmination of overflow whereby the southwest pond, now partially shut off from the main lake, flooded the entire south valley from the west cone to the rampart of the southeast cove. The lake at this time was only 60 feet below the rim. So voluminous was the overflow filling of the south depression that it pooled, crusted and then the crust cracked up and foundered, leaving wide smooth surfaces with little trace of the original festooned skins. All of this suggested that the January rise of 1917 was repeating itself.

During the week ending at 2 p. m. January 4, 1918, the seismographs of the Whitney Laboratory have registered no local earthquakes, but two teleseisms, or distant great shocks, were recorded on Saturday, December 29. At least one of these originated in Guatemala, and probably both of them. The first shock began at 7:45 a. m. Hawaiian time, or about 12:15 p. m. Guatemala time. Its first preliminary phase occupied 7 min. 40 sec., corresponding to a great circle distance from Hawaii of 6070 kilometers—a close approximation to the distance of Guatemala. The second and greater shock reached the Observatory at 12:50 p. m. H. S. T. or approximately 5:20 p. m. Guatemala time and wrote its record for about 30 minutes. The preliminary phase indicated an original approximately distant about 6400 kilometers, which is near enough for the Guatemala center. The great circle distance from Honolulu to Guatemala city is approximately 3945 miles or 6365 kilometers. The first preliminary wave front sent through the earth from Guatemala should travel at a rate to reach Hawaii in about nine minutes. This would make the actual

earthquakes in Guatemala 12:04 p. m. and 5:11 p. m. Guatemala time. The writer has not yet seen reported the hours of the shocks which finally wrecked the city.

Microseismic movement during the week has dwindled to nearly normal, and there has been nothing unusual in the motion of volcanic vibration. Tilting to the north and east, of no great amount, took place during the recent sharp rise of the lava in Halemaumau.

January 12, 1918.

During the week ending January 11, 1918, the rapid rising of the Halemaumau lava column has continued, and renewed activity at the old west and northwest cones above floor-cracks is interesting confirmation of the view that those places are permanent conduit wells of much importance in the mechanism of the rising lava, although they remain crusted over and obscure for months at a time. There has been a change in the habit of the lava lake since the solstice, with increased speed of streaming to the south sinkholes, thinner crusts, more fountaining, relatively sudden overflows alternating with sharp risings of the crag masses and increased gas pressure at the western conduits, building driblet cones and driblet flows from floor cracks. These effects suggest that the sun's turning point, affecting fissures underground filled with rising magma which had been under uniform stress during the sun's southing for three months, brought about a relatively sudden release of stress and reduction of pressure on gas-charged lava. Increased volumes of gas would escape from solution generating heat and inflation in the upper part of the lava column, but the net effect eventually on the magma below would be subsidence. Such explanation accounts for the paradox of subsidence symptoms such as sinkhole cascades coupled with sharp rising. This paradox was the fact at the beginning of January both last year and now. An important result of this analysis, if true, is that the observed immediate effect of an astronomical crisis on the liquid lava may not necessarily be the actual mechanical effect due to stress on the fissure system. In other words, measured rise and fall of lake magma and bench magma at the surface is not the rise and fall of the main lava column deep down, and even the lake levels and crag levels reach their culminations on different dates. To determine the critical times when the deep lava column reaches its highest and lowest, an equation must be worked out which is by no means simple.

Measurements on Saturday, January 5, 1918, at noon, made the depression of the lake 61 feet below the east rim of the pit while both the east island crag and the central crag stood 17 feet above the level of the rim. In seven days the lake had risen 17 feet and the two crags 15 feet.

Strong rising and overflowing was in progress and fumes were thin. The southeast inner bench under the southeast shelf of May, 1917, was overflowed continuously from 11 a. m. to 12:30 p. m. There was great heat on the rim, and strong gas pressure and puffing were evident at the spatter domes of the southeast cove. At the east gulch a high driblet cone with stalactites had been built. The inner bench was two to three feet high. Streaming was northward in the main lake, southeastward in the southeast arm and very rapid to the tunnel grotto at the west side of the southeast cove. The increased movement upward of the crags produced occasional falling rocks from slopes and cliffs facing away from the center of the pit. There were hot blistered thin crusts at the southeast cove and heavy polygonal crusts separated by bright lines over the central region and southeast arm. Occasional large migratory fountains would form with swarms of bubblings. At the southwest pond there was rapid streaming from west to east and the hissing vent above the tunnel extending from it southeastward was maintained through the new overflows there. So was the large smoke patch southwest of it.

At 1:30 p. m. the lake was generally crusted and high, border fountains at the southeast margin of the southwest pond splashed over into a small overflow and there was heat crackling at the hissing vent there. Tremendous fountaining was in progress at the southeast cove tunnel grotto with very rapid rush into it as though it led to a sinkhole. The margin of the summit

pond was only about two feet high. The west bank of the main lake south of the old west crag mass had been warped up into a cliff 20 feet high. At 11:55 a. m. the eastern summit turret of the central crag mass, or what was left of it, fell with a crash into the central valley and a cloud of red dust shot up. At 1:45 p. m. in the southwest pond there was general breaking up and temporary subsidence with strong streaming from the west. At 2 p. m. the north arm was quiet and heavily crusted and the lake at the northwest cove was brimming level with the bank. At 2:15 p. m. there was general cracking and foundering over the whole lake with violent fountaining and temporary subsidence by about two feet. The break-up was noisy and an overhanging bright rim showed on all sides. The disturbance began with a violent fountain in the southwest arm. Between the large foundering crust area lines of bubble fountains broke out. After the breaking-up immediate recrusting set in.

The south valley was now covered with a fresh flow extending all the way from the west cone to the southeast rampart and there was a similar flow covering the whole northwest shelf to the old west crag mass. The east cove had a new overflow floor and spatter dome. The southeast cove on its south and west shores had not overflowed, owing probably to the rise of those banks along with the crags. A distinct ridge extended from the west crag mass southwestward to the west cone. The northwest crag had now become a steep hog-back with upper surface inclined eastward. The uplift of the whole central and northwestern group of crags appears to offset the flooding of the western and southern depressions. Seen from the northwest station the east ledge was now well above the southeast shelf, the southeast crag was only slightly below the edge of the pit, the east island crag towered above everything and it was evident that all the central peaks stood high above the top of the wooden A-frame at the south station.

At 3:20 p. m. there were heavy falls of rock from the central and southern crags. At 3:50 p. m. overflowing was resumed along the inner bench from the east gulch southward, building up that bench and diminishing the height of the southeast shelf above. At the southern end of this growing bench the southeast grotto was surmounted by a spatter dome and back of it ten feet from the edge of the lake a lava pot eight feet in diameter had formed whence spurts would be thrown twenty feet into the air. At 4:30 p. m., a heavy fall of rock into the lake from the north inner cliff started prolonged fountaining there.

On January 6 at 2:15 p. m. the inner bench was eight feet above the lake, there was activity at the central cove and the southeast arm was crusted. At 3:30 p. m. nearly half of the new southeastern inner bench collapsed, followed by a similar collapse of the bench protruding from the southeast crag and finally there was collapse at the southeast tunnel entrance. All of these falls made violent fountains in the southeast arm and cove. At 4:30 p. m. there was much tumbling of fragments from the sides of the east island crag. By 6 p. m. the temporary subsidence made the inner bench ten feet high and there was active fountaining everywhere and very swift rush of surface currents to the southeast tunnel.

On Jan. 7 at 11:30 a. m. the lake was high, crusted over, and the streaming with great emission of heat from the southeast point to the tunnel was estimated to flow at two feet per second. The southeast grotto continued active and the pot back of it was smaller. The dome and the bench at the east cove had collapsed, but there was a new spatter grotto forming at the east tunnel. The bench at the southeast point was six feet high but across the stream to the east the bank was only two feet high showing that the southeast crag was still rising. The floor of the east gulch appeared very low as though overflow into it were imminent. The southwest pond was crusted over, there was bubble fountaining under the isthmus bounding it on the west and a fountain noise came from the tunnel at its southeast corner. There was no hissing from the blow hole above. A large spatter dome stood on the bank of the pond northeast and in general its border was from six to eight feet above the lava within. At 11:30 a. m. rising lava overflowed the crust on the pond from

west to east. The west cone ridge and west inner cliff of the lake appeared higher as though rising from the crags. Under the face of this cliff was a cavernous grotto probably where the west tunnel emerges at the lake. The northwest cone area was whitened, smoky and very hot. At noon there were fountains in the center region of the main lake and against the north and east sides of the southwest pond. There was only sluggish inflow to the tunnel at the southeast corner of this pond. The northwest crag now appeared level with the edge of the pit.

On Tuesday, January 8, at 1:30 p. m. there were twelve fountains active in the southeast arm and the lake was some ten feet below the inner bench. The north arm was crusted and the pit smoky. The southwest pond at 2:50 p. m. showed a margin 10 feet high and several active fountains. About this time there was a fall of rock from the central crag. At 6 p. m. the lake had risen about five feet and there was great activity at the southeast grottoes and swift rushing to the tunnel there.

On January 9 at 4:30 p. m. the lake was high and the southeast inner bench only one foot above it. The southeast point was five feet above it. Thin crusts covered the lake and there was swift streaming to the southeast tunnel, now very active. In the morning this tunnel had been quiet. The east ledge was now much higher than the southeast shelf and this lift was seen to extend along the inner cliff bounding the northeast floor on the lake side, clear around to the northwest crag. The fume was rather dense. Occasionally large fountains broke out in the channel leading to the southeast cove.

On January 10 at 2:30 p. m. the floor of the east gulch was found to be flooded for a long distance in the direction of the east station and the southeast inner bench showed fresh overflows. There was the same swift streaming to the southeast tunnel. At 2:40 p. m. a portion of the bench at the southeast cove collapsed, started many fountains and immediately thereafter there was subsidence of about three feet in the southeast arm. The southeast tunnel sprayed and fountained violently but the north arm remained covered with crust.

On January 11 at noon the inner bench was seen to be built up so as to make the southeast shelf much lower than the cliff above it as seen from the south station. A new twelve-foot driblet cone with a sharp pointed summit had been built at the northwest cone locality and occasional puffs were heard from it. There were glowing and puffing cracks at the base of the west driblet cone and steady hissing was heard in that vicinity. There were new festooned overflows from the northwest cove to the base of the west shelf and a long driblet flow had poured from the northwest cone to this shelf and then northward along its base for 300 feet. There were other fresh overflows from the southwest pond to the south valley and the southwest pond had contracted in size. The tunnel locality southeast of it showed glowing cracks which hissed, and sulphur stain. The west cone ridge and all the crags continued to rise. New crevasses had formed between the west and northwest cones and a great open crack extended northward from the latter along the western base of the old west crag mass.

The inner bench of the lake in general was about four feet high and around the southwest pond six feet high including a considerable rampart. Cracking and foundering was in progress at the north cove, polygonal skins moved with a rapid current in the southeast arm, there was swift rush to the southeast tunnel, dome grottoes rose above the coves and individual rocks were falling on the sides away from the lake of the several crags and ledges. This all showed that rapid upward movement was in progress. The noise of central fountains was continuous. There were solfataric smoking areas southwest of the southwest pond and south of the northwest cone. Smoke also rose from the floor opposite the northwest cove indicating the presence of the old tunnel below connecting that cove with the northwest cone conduit. There was also dense smoke from the central steeple and the north smoking crag. The east island crag now appeared unquestionably the highest object in the pit, and the east ledge appeared nearly level with the east station. The current was now out of the north arm into the southeast arm and occasional

fountains in the latter would migrate around the southeast point and expend themselves against the south side of the southeast crag with swirling and very swift currents.

Measurements on this day, Friday, January 11, 1918, at 1 p. m., made the depression of the lake 57 feet below the southeast edge of Halemaumau and the bench of last overflow two feet higher. The east island crag was now above the rim of the pit 30 feet, the central crag 28 feet and the southeast crag 2 feet. The east ledge was below the rim 7 feet. These figures indicated that the lake had risen in six days 6 feet, the east island crag 13 feet and the central crag 11 feet. The crags had thus maintained their rapid rate of rising but the lake had slowed down. Since December 21, that is in three weeks, the southeast crag had risen 25 feet and the east ledge 31 feet.

In the Whitney Laboratory of Seismology for the week ending at 2 p. m. January 11, 1918, two small local earthquake shocks from origins not very near Kilauea were registered about 4:50 p. m. January 5, and about 3:02 a. m. January 7. Microseismic motion increased during the week and volcanic vibration remained slight, increasing a little. Tilt strong to the north and stronger to the east reached a maximum January 8-10 and declined on the 11th.

January 19, 1918.

During the week ending Friday, January 18, 1918, the lava column of Halemaumau has continued to rise, the lake averaging one and a half feet per day and the crags two feet per day. The east floor, where so many people descended during the summer, is now a mighty crag upheaved above the edge of the pit quite like the east crag of a year ago, and blocking the view of the lake. The rising of the week has proceeded by alternations of inflation of the lakes and rapid liftings of the crags, the latter, as before, rising more than the lake. The overflowings of the latter are small and insignificant in comparison to the bulk of new space occupied by the whole mass. Vast swellings-up of the bench magma under the floors, causing intumescence and gaping crevasses, indicate how large a part of the rise is due to this heavy mass. The bench magma fills the pit from side to side, makes the bottom of the shallow lake, and occupies a much greater area within the pit walls than the lake. In the middle of the great central crag there is one peak which has repeatedly risen, toppled southward and fallen. This appears to be the top of a rising pencil of the bench magma, like the Pelee spine in Martinique, less viscous than the shells around it, and so rising faster. Probably these shells are concentric, rising least near the outer walls, or even there subsiding in part. The bottom of the northeast valley is again far below the level of the lake, just as it was in May, 1917.

At 12:15 p. m. on Saturday, January 12, the inner bench southeast was three feet above the lake, the streaming was rapid around the bend to the southeast tunnel but the central region was quiet. At 2:30 there were eight traveling fountains migrating toward the tunnel where there was violent effervescence with rumbling. At 4:15 p. m. a block from the southeast crag fell into the lake and started great activity in the southeast arm. At 6:30 the lake had risen level with the east gulch bench.

On January 13 at 1:45 p. m. looking from the northwest the lake magma of the north arm was seen to be ten feet below the northwest floor, the north arm was quiet and crusted over and smoke in that region was thick. Looking from the north the east island crag out in the center of the pit appeared fully 30 feet higher than the north inner cliff and the northwest crag was also somewhat higher than this cliff. At 2:30 p. m. the maximum activity as usual was in the southeast cove with swift streaming toward the tunnel there. At 3 p. m. a heavy slide of rocks fell from the east summit of the central crag with much noise. At this time the southwest pond was crusted over and quiet.

On January 14 at 12:30 p. m. the lake was about ten feet below the inner bench and the latter along the east island shore showed horizontal spatter lines below and a lumpy rampart above. A large dome had been built on the south side of the central cove. There was strong rush to the southeast tunnel but elsewhere the lake was quiet. The northwest cove recently obliterated

through extension of the northwest floor which probably arched over it, was found on this day to have collapsed open again to a wide and deep cove which greatly widened the north arm of the lake. In the middle of the cove a pile of crusts made an island. At its west shore the floor was swollen up and cracked. Such swelling was very conspicuous in the region which may now be called the west cone ridge, an area of intumescence extending from the west cone to the west crag mass. Here the rising had been so rapid that the west cone was now level with the west shelf and the area around it was cracked and whitened. The west and northwest cones were glowing and hissing and two smaller cones had been built in line next south of the latter. The north cove spatter dome had an open glowing gash on its summit. The west bench of the east island mass was deeply crevassed. The high crag of this mass is an upright slab, thin in the southwest-northeast direction and very wide at right angles to this. The northeast floor had now become a table crag fully 1100 feet long including the east ledge, the northeast peak and the north smoke crag, all of these now level with the edge of Halemaumau. The southwest pond had diminished in size and the tunnel southeast of it was now surmounted with an open ragged pot glowing within a half-dome of spatter and stalactites built above it. There were no fresh overflows, the strong rising being confined to the crags.

On January 15 the crags were so high that practically all of them were visible when seen through a telescope from the Observatory. This included long stretches of the east ledge, the north smoke cliff and pinnacles of the northeast peak. The fume was very thin. At 2:30 p. m. the southeast overflow bench was one foot above the lake which was quiet with very disagreeable sulphurous fumes arising from the southeast grotto. At 3:45 p. m. the lake was flush with the bench and there was much fountaining at the base of the southeast crag. There were also central fountains in the southeast arm.

On January 16 at 2:30 p. m. the southeast inner bench was three feet high, the southeast cove was active and there were fountains in the southeast arm. The continued lifting of the east crag mass had undermined the new shore bench at the east cove so that it had completely collapsed along with the spatter dome at the east tunnel. There had also been falls of bench matter at the southeast tunnel. From the south it was seen that similar collapsing had taken place at the pot over the tunnel adjacent to the southwest pond on its southeast side and there was now a glowing cavity there some ten feet in diameter. At 5:10 p. m. a portion of the southeast cove bench fell in and the lake was brimming. At 5:20 it overflowed the bench from the east gulch southward.

On January 17 at 2:15 p. m. the great activity at the southeast tunnel had ceased and the lake was high at the new bench level. There was much activity in the central cove and in a new grotto south of the central channel. Some very large boulders fell from the central crag which was continually scaling off, this indicating motion there. A grotto under the southeast crag was boiling vigorously and spurting. From the southwest station at 2:45 p. m. the southwest pond was seen to be crusted but the tunnel grotto was puffing with great activity. At 3 p. m. the pond subsided a few feet and fountains broke out there. Looking northward the lake was seen to be very quiet except in the north cove grotto. Dense smoke rose from the bench southwest of the southwest pond.

Measurements on Friday, January 18, 1918, at 11 a. m., determined the depression of the lake to be 47 feet below the rim of Halemaumau. The east ledge was now 8 feet above the rim, the east island 43 feet and the central crag 40 feet above the rim. In seven days the lake had risen 10 feet, the central crag 12 feet, the east island crag 13 feet and the east ledge 15 feet. The ledges had thus moved much faster than the lake and the maximum rising was under the great northeast floor area.

On this day the conspicuous feature was the east ledge which had so risen that the whole depression under the 1894 bench was cut off from the view of the southeast station while from the east station this ledge cut off the view of the lake except through the east gulch. This gulch had become a deep

canyon leading to the V-shaped valley which now extends along nearly a half of the circumference of the pit at the base of the walls on the northeast. What had been the floor there was now tilted up at 35°, the great northeast crevasses were closed by the back pressure and this northeast ledge duplicates the 1894 ledge on a much greater scale.

In like manner the southern area had been lifted bodily and even the new south valley flows were tilted southward and swollen up along great north-south crevasses which gape open from a point under the south station across the back of the south crag and up to the central crag. This area is thus swollen up along a north-south axis. Similar swelling had continued at the west cone ridge, the general surface of which was now level with the floor of the west shelf and both the west and northwest cones were now above that level. A line of pressure ridge extended eastward from the west cone. Two new driblet peaks had formed on the north side of the northwest cone. The shores of the southwest pond and southeast cove had both been lifted. This lifting of the southwest pond basin along with the adjacent central crag is a relation precisely like what the northwest pond was to the west crag mass of November and later, 1916. The phenomenon shows that the conduit and sinkhole wells are themselves warped, lifted or depressed with the movement of the bench magma. The bench at the southeast point was upraised and there were now three benches in the profile of the southeast crag above the actual lake rim which at the time was about two feet high. Another evidence of new swelling appeared across the east island mass along a southeast-northwest axis, the broken bench on the east cove side being upraised in the middle with the two pieces tilted respectively northeast and southwest. The shores of the central region of the lake were now a complex of benches lifted to various heights. The east summit of the central crag mass showed a new proturberance toppling southward and avalanches fell from its summit. It appeared ready to fall at any moment. This was at precisely the same point where similar peaks fell twice a few weeks ago. It has been replaced in the meantime, although the west summit immediately adjacent has remained unchanged.

On this day the southwest pond was crusted over, but there was a break-up and temporary subsidence of a few feet at noon. There was a similar breaking-up in the main lake. The tunnel heap southeast of the southwest pond no longer showed an open pot and the place was quiet except for some hissing. The southeast cove was rather quiet, the southeast dome grotto high, glowing and hissing, and there was vigorous streaming and fountaining in the southeast arm. Rocks were sliding at the east gulch. There was an active grotto at the end of the west arm, probably at the tunnel under the pressure ridge which heads toward the west cone. Streaming was northeastward from the west arm and northward in the main lake.

In the Whitney Laboratory for the week ending at 2 p. m. Friday, January 18, 1918, three small local earthquakes have been registered all apparently of origin near the volcano. Two were on January 13 at 1:17 p. m. and 1:36 p. m., and the other, felt in Volcano House district, happened on the 17th at 3:18 a. m. There was a vague teleseism indicated at 7:07 a. m. on the 14th, the phases masked by microseisms. Microseisms have increased during the week, volcanic vibration has been normal. East tilt, which was very strong last week, has decreased but tilt to the south has become very strong.

January 26, 1918.

During the week ending January 25, 1918, the recent excessive rise of the lava culminated January 24, the lake reaching its limit with overflows the day before. On the 25th subsidence set in, the lake sank over twenty feet, there were profound changes in the crags, the great east island tower crumbled into the center of the lake, new islets and coves arose in the northern region and the crags generally settled to lower levels. The change was heralded in advance by whirlpool action and increased streaming and fountaining towards the southeast. All of this checks perfectly with what was to be expected when the solstice effect of sharp rising had expended itself and the reverse movement begins on approach to the equinox. It

will be remembered that just such a change came at the end of January last year and it is remarkable how closely accordant in level the average maximum height has been, as reached by the liquid lava in the pit January, 1910; January, 1912; January, 1917; May, 1917, and January, 1918. All of these were just before or just after the solstice. The maximum height and volume of the visible bench magma, however, has increased greatly and progressively with the last three of these culminations, so that the mighty crags now lifted high above the rim of Halemaumau surpass anything of the kind seen here for over thirty years.

On Saturday, January 19, 1918, at 3 p. m., the inner bench was about 10 feet above the liquid lava and this may have been largely by rise of the bench magma, for the rampart material at the southeast cove had fallen leaving vertical walls and a similar effect was observed in the southwest pond. This was no longer a separate pond for the collapse had again opened the channel connecting with the main lake. Streaming was slow and the north arm was quiet and crusted over.

On January 20, at 1 p. m., the lake was heavily crusted and unchanged in apparent depression. The south bench was smoking heavily. At 1:30 p. m. a pronounced collapse was seen to have taken place in the southeast cove developing a new grotto and another fountaining cavern was noisily active under the southeast crag. Inspection of the high east island tower from the southeast showed that much of the summit region on the side toward the center of the lake had fallen away, greatly changing its profile. During the afternoon the lake was quiet but in the evening strong rising and increased gas pressure appeared and at 6:30 p. m. the surface of the lake was flush with the southeast bench. At 7 p. m. the lake overflowed at the east gulch.

On the morning of Monday, January 21, from 9:30 o'clock on the lake began a succession of powerful overflows which were destined to recur at intervals during three days. The overflows on this morning were dominantly through the east gulch into the great northeast valley, but there were others from the southwest pond into the south valley. It was evident also that there had been fresh flows recently from the northwest cove, making a new area of pooled lava which had cracked and foundered extending from the northwest crag along the base of the west shelf to near the northwest cone. Since that overflow the whole northwest floor had risen and tilted westward so as to make a new cliff over the lake. The west floor clear across the pit from the west cone ridge northward was thus another unit tilted away from the center by being swollen up from below. The west shelf above this floor was now low, the west cone was hissing and the great crevasse on the east side of the row of northwest driblet cones was filled with active lava making an elongate pond which exhibited a splashing grotto five or six feet below the base of the northwest cones. The latter stood on the western lip of the chasm This new appearance of a western pond reaffirms the persistence there of a conduit well.

The great spectacle of this day was the torrent pouring like a mountain brook of liquid fire through the east gulch from 9:30 a. m. to 1:30 p. m. continuously. The flood moved as a rill some 300 feet and then pooled for a length of 600 feet or more under the 1894 bench. The torrent was from five to ten feet wide, hemmed in by a congealed strip on each side and moved at a rate estimated at ten miles per hour from the progress of crusts floating down the current. The under-rush beneath the surface may have been somewhat faster. The torrent seemed to erode its bed of bowlders, for the slope of rocks on the east ledge side was continually slipping so that on one occasion a tumble dammed the stream and made a temporary cascade.

There were six or more great fountaining areas in the lake, notably on the north, west, northeast, southeast and at the northwest and southwest ponds. The southeast shelf stood only about four feet above the lake with a great fountain splashing over it as on May 31 last. The resemblance to the May culmination was remarkable in other respects, such as the revival of the western cones, the formation and filling of the great northeastern valley and the uplift of the east ledge. On this morning the inner bench overflowed

at the east cove and there were other flows at the northeast and central coves, the flood at the latter filling the depression west of the southeast crag. The floods filled crevasses about the southern margin of the southeast cove and new chasms filled with lava appeared in the direction of the south tunnel. The southeast crag had been tilting northward and showed a fresh broken wall and talus on that side. The core of the central crag again stood out as a turret ready to fall southward and the steeple east of it exhibited once more a sharp needle-like summit while its south face was red, smooth and perhaps striated. Rocks were tumbling into the north pit and other falls indicated instability and motion in the crags always away from the central region.

The flood into the northeast valley produced only carbon odors above. This flood did not continue long into the afternoon and the pool there was not deep like the one of May 31, 1917, but was rather a very long pahoehoe flow with festooned upper surface and toes percolating the bowlders.

Measurements on January 21 at noon determined the lake depression to be 40 feet, and the elevation of the several peaks above the rim of Halemaumau to be as follows: East island crag 40 feet, central crag 38 feet, north smoke cliff 11 feet and east ledge 8 feet. In three days the lake had risen 7 feet, the east island crag had lost 3 feet, the central crag had lost 2 feet and the east ledge was unchanged.

On January 22 at 3 p. m. the lake was flush with the bench southeast. At 3:45 p. m. slow overflow of the bench began and by 4 o'clock the flow was vigorous, pouring into the east gulch. At 4:30 the flood was level with the southeast shelf and in places overflowed it. At 11 p. m. there were extensive overflows. Throughout all of this, however, the filling of the northeast valley was only moderate, the upper surface of the flow there remaining ropy and festooned and at no time did the pool become deep enough to crack and founder as in May last. The 1894 bench remained high above the new filling and cracks in the latter indicated that the bottom of the valley subsided somewhat after the flows cooled.

On Wednesday, January 23, at noon, the lake stood two feet below its new southeastern rim. The southeast shelf was nearly completely buried under fresh flows and the new bench from lake to cliff was twice as wide as the southeast shelf had been. The flow had poured along the base of the wall southward to a point under the south station. Glow persisted in the cracks of the fresh flows. The depth of the northeast valley appeared unchanged. The southeast cove was wider and longer and south of it was a great uplifted tumble which restrained the cove from overflowing in that direction.

The lake was 22 feet below the southeast station. At 1:30 p. m. overflows began at the east gulch, southeast ledge, around the base of the old west crag mass and probably from the southwest pond also. The flow through the east gulch was not prolonged but the flooding southward was considerable. Back of the rampart at the central cove was a depression much below lake level which eventually received flows.

The southwest channel was open and when the circuit of the pit was made fresh flows were found on the floor extending southward from the southwest pond. A flat-topped islet stood in the northwest cove. The west cone had given vent to a considerable flow southward but the lava in the northwest chasm pond was quiet. The activity in the main lake showed high gas pressure, ballooning skins and flames, occasional great central fountains and five or six grotto fountains.

The crags were higher than ever and all of them above the edge of the pit except the old western crag mass. A great turret hung out ready to fall from the southern side of the summit of the central crag. As seen from the north the northwest crag and north smoke crag appeared much alike with a notch between them.

At 9 p. m. a sudden subsidence in the southeast cove developed a standing rapid at its narrowing entrance channel and a whirlpool was produced on the north side of this rapid which created a marvelous display for ten minutes.

Seen from Uwekahuna bluff at 8 p. m. the pit was an extraordinary spectacle, the crags outlined by the illumined fumes and the main lake in full view with streaming from the southwest arm

to the southeast arm and a fountain against the western base of the east island crag. Glow could be seen at two places near the western cones. On this day the fountaining noises could be heard, and the splash of the fountains seen, even from Volcano House.

On January 24 at 3 p. m. there were fountains in the north arm, the southwest arm was crusted, fumes were thin and the inner bench northeast was about 5 feet high. There was fountaining at the west and southwest tunnels. At 3:30 p. m. the southeast arm was crusted and rising slowly, the southeast grotto showed a flaming pot above and there was active fountaining under the southeast crag.

From 4 to 5 p. m. the lake was 5 feet below the new southeast bench, there was streaming to the southeast tunnel, occasional migratory central fountains formed and streaming in the main lake was from the south and the north, the two currents meeting at lines of fountaining west of the east island mass. The southeastward streaming in the southeast arm occasionally became masked by crusting. During temporary subsidences wide overhanging margins two to three feet high revealed stalactites and glowing walls. Rocks were moving in the east gulch and on the northwest side of the northwest crag. The pond back of the central cove occasionally broke up with cracking and foundering and there was revealed a narrow channel leading to this pond on the west side of the southeast cove.

This time was the climax of swelling upward of the crags. On this day the north and northwest crags rose more than the others and the southeast crag had tilted over northward, its tip had fallen off, the southeast point was tilted up 8 or 10 feet above the lake. There was a fresh flow along the southeast bench and through a gap in the uplifted area under the south station, pouring thence westward the whole length of the south valley to join other festooned flows fresh from the southwest pond. The break or gap through to the central cove pond from the southeast cove appeared to be the crevasse formed by the overturning northward of the southeast crag mass. The west cone ridge had lifted higher. The floor bordering the northwest and west sides of the north arm was 8 feet high and the islet, of similar height, stood in the northwest cove as a mushroom. The north cove bank was lifted into a cliff with the spatter dome of recent formation on top.

On January 25 there was a heavy rainstorm, but the lake was reported sinking, and the east island crag crumbled to a ruin.

The seismographs of the Whitney Laboratory for the week ending at 2 p. m. January 25, 1918, have recorded seven local earthquake shocks as follows: Small shock, 7:55 a. m. Jan. 19; on Jan. 21 at 11:23 a. m., 12:59 p. m., 2:29 p. m. (the strongest), and 2:40 p. m., all small; on Jan. 23 at 4:35 p. m. and on Jan. 24 at 8:46 a. m., these also small. Microseismic motion was strong early in the week and decreased later. Volcanic vibration has been moderate, with slight increase in spasms after the 24th. Tilting increased northward and eastward, the south tilt becoming extreme Jan. 24-25. There have been thunder, lightning, hail and southwest gales during the week, extremely heavy rainfall amounting to nearly eight inches, and heavy snow has fallen on Mauna Loa and Mauna Kea.

February 2, 1918.

During the week ending Friday, February 1, 1918, the subsidence which began on January 25 continued for three days and then the lava turned and rose again after reaching a depression of approximately 50 feet below the rim of the pit. The rising has been interrupted by unusually strong pulsations of sinking and at the end of the week the depression of the liquid lake was 44 feet below the rim and the crags were stationary. The sinking spell destroyed the great East Island tower, produced strong overturning northward of the southeast crag, developed a new pond west of that crag, opened the channel to the southwest pond and developed a remarkable chasm extending from the northwest pond to the northwest cove. The topography of the north arm has completely changed.

On Saturday, January 26, from 3 to 6 p. m., a visit to the pit after and during the prolonged rainstorm which had been in progress for three days, reveal-

ed the fact that a change to subsidence had taken place, foreshadowed by the southeastern whirlpools of January 23 and the culminating rupture and overturning of the southeast crag January 24. The lake was now 30 feet below the new southeast bench, only a small low horn remained of the east island tower, and the other crags had lost height. There was vigorous southeastward streaming, border fountains surrounded the southeast cove, a cavern grotto had formed under the gateway leading to the central pond, the latter occupying the depression west of the southeast crag and showing a crusted surface 15 feet above the liquid lava of the cove. The southwest pond lay 30 feet beneath its bordering walls, showed a tunnel grotto at its northeast corner, and hot blue fumes southeast. The west cone ridge appeared lower and showed a glowing heap south of the northwest cone. At 3:20 p. m. the north arm as seen from the northwest exhibited a sudden subsidence, breaking up of crusts, violent recession of the lava to a central depression across shoals which emerged at the northeast cove and there was intense and noisy fountaining. High glowing margins were revealed. This episode was followed by a crusting over of the lava with grotto fountaining at the north and slow rising.

At 4:30 p. m. the writer climbed to the summit of the north smoke crag and found great changes in the north arm region. This region was now the largest pond area by far, and was separated from the central region by a narrow channel. The northwest cove was greatly extended along the line of the chasm leading to the northwest cone and a high cliff had been lifted west of it. There was a new cove in the midst of the west crag mass, two peninsulas had been built out westward from the east island mass and three islands had formed in the northern lake thus isolated. The narrow channel forming its outlet southward occasionally became the scene of a steep torrent when the lava of the southeast arm subsided faster than that to the north.

At 4:30 p. m. the streaming was from the northwest cove to the active north grotto, and otherwise out of the north lake and out of the southwest arm, the two currents uniting to pour into the southeast arm. During sinking spells the crusted lava of the north lake showed cracking and foundering and the southward streaming through the narrows became almost a cascade.

The new peninsulas adjacent to the east island mass were probably built from the debris when the east island crag crumbled down. Probably the north lake bottom rose to form the islands owing to a reaction and settling back of the crags after their recent elevation.

The southeast crag had subsided bodily, lost more of its summit and a new inner bench against it had been built five feet above the lake surface. A similar lower platform bordered the east cove and the north lake. There was one heavy fall of rock into the lake from the northeast corner of the southeast crag. The great northeast crag ridge remained elevated and at the same high angle of tilt. Glow was still visible in the southeast overflows.

On January 27 at 2:30 p. m. the lake was still low and crusted except for two fountains in the southeast cove. Much of the inner bench under the east island mass had fallen away. The southwest arm was also quiet. At 3 p. m. the central pond showed two small cones, one of which was puffing, and a pot with lava three feet below the bench around it. At 6:30 p. m. the pond had grown larger and was fountaining in two places.

On January 28 the lake was low and quiet, there were some rock falls, little fountain activity and in the evening flames were abundant.

On Tuesday, January 29, 1918, the lake at the southeast cove was 20 feet below the southeast shelf, subsidence was in progress, there were many fountains in the southeast arm and a few in the north lake. At 3 p. m. the central pond, now a circular pit 20 feet deep and 20 feet across with lava at the lake level, was crusted over and hissing slightly, showing glow through cracks of the crust. The southwest pond was in process of breaking up with vigorous fountaining and streaming and the grotto at the south tunnel corner was surmounted by a puffing cone honeycombed with flaming apertures. At 4 p. m. both the southeast cove and south-

west pond were 15 feet below the floors. There was the usual activity southeast with slow streaming, occasional central fountains and border fountains at the southeast grotto and the southeast tunnel. The middle of the lake was quiet, streaming was northward from the west arm and the southwest channel was open. The southwest pond was crusted over, sluggishly cracking and foundering, there was a fountain against its east bank and the skin heaved outside of the south tunnel grotto. Both the southwest and southeast coves showed a new spatter margin three feet above the lake indicating a rise and the crags were higher.

The lake was pulsating strongly. At 4:30 p. m. there was sudden subsidence leaving glowing margins three feet high and violent fountaining ensued, one of the fountains in the southeast cove migrating northward and reversing the direction of streaming for a few minutes. There were violent turbulence and cracking of crusts. Then the lake recovered. Under the heavy rain the vaporing of the recent hot flow surfaces was conspicuous and millions of steam tassels formed on the crusted portions of the lake. At 6 p. m. the lake was within one foot of its new spatter margin.

On January 30 the lava was reported very quiet and apparently sinking. On Thursday, January 31, at noon, the lake was 20 feet below the southeast bench and rising, with a new construction rim about it. A new floor and spatter dome appeared at the east cove and fresh overflow surfaces covered wide areas around the north lake and the islands and peninsulas there. The southeast chasm leading from the southeast cove to the central pond had widened. As seen from the south-southeast the profile of the gap between the steeple and the central crag had remarkable U-shape and the laminae west of this gap showed tendency to flare upward in their bedding. The south face of the steeple appeared smoothly striated vertically as though scraped by pushing upward against a fault surface. The southwest pond was low and surrounded by inner cliffs. The southeast crag showed a fresh fall of rock from the tip of its upraised southeast escarpment. This crag has recently changed position horizontally and moved northward owing to the gradual shift of its upper part west and north and the continual rebuilding of its lower part at the southeast point. Its upper escarpments show west tilt but its lower portions have been tilted northward.

The swelling up of the west ridge had now increased to such extent that a wide chasm had been developed extending all the way from the northwest cone to the west cone, the group of driblet spiracles of the northwest cone standing on its west margin. The chasm was probably increased in size by collapse of its margins when the recent subsidence withdrew the lava of the northwest pond. The west ridge on both sides of this chasm was now a swollen dome with the old west crag mass on its east flank.

The north arm had now become a large roundish lake full of islands and flats and the channel with southward streaming lava leading out of it was now a greatly constricted curving ditch almost separating it off from the southern arms. The remains of the east island turret appeared from the northwest like a narrow upright tower of great slenderness. The central crags towered up as high peaks but the northeastern crag ridge appeared lower and the lake appeared to be encroaching on the east island and western crag masses. There was a tumbled cove opening at the lake end of the west tunnel and the west cone appeared broken.

Streaming was rapid to the southeast, there were central fountains, border fountains played at the southeast cove, crusts showed tendency to balloon upward over rising gas from beneath, fumes were rather thin and there was occasional subsidence of a few feet with accelerated streaming. The islands in the north arm stood only five feet above the lake where a few fountains burst irregularly. At 2:30 p. m. the east cove bench was three feet above the lake and rising was in progress. Two fountains were in action at the central pond and the southwest pond was lively, especially at the south tunnel grotto. At 5 p. m. the lake was brimming level with the new bench at the east cove.

On Friday, February 1, 1918, at 4:30 p. m., the lake was high and rising, so

that by 5:30 p. m. it was brimming level with the new marginal bench everywhere and overflowing it in places. The noise indicated high gas pressure which ballooned the crust and made many flames. Central fountains formed and migrated with the current. At 4:30 p. m. a heavy fall of rock from the north side of the southeast crag into the lake produced intense fountaining so that the rising hot gas started a whirlwind which carried up flakes of the broken lava and made a noisy display for the greater part of a minute. The fume was very thin, the crags in general remained stationary and there was much luminous fountaining in the evening, especially in the northern, central and southeastern regions.

At the time of subsidence, Saturday, January 26, at 4 p. m., rough measurements made in a rainstorm determined the depression of the lake to be 48 feet. Measurements on Friday, February 1, 1918, at 5 p. m., determined the lake depression at the southeast cove to be 44 feet below the south station. The elevation of the central crag above the south station was 46 feet and of the east ledge 17 feet. The lake thus from its high level of 22 feet below the rim, January 23, subsided in three days 26 feet and thereafter in six days recovered 4 feet. For the crags during the interval January 21-February 1 inclusive, eleven days, there was moderate rising, 8 feet for the central crag and 9 feet for the east ledge. The net movement of the lake for the same interval is slight subsidence (4 feet), for it must be remembered that the lake rose suddenly 18 feet January 21-23.

The Whitney Laboratory instruments have registered for the week ending at 2 p. m. February 1, 1918, four slight local earthquake shocks and one distant strong shock. The local earthquakes were at 11:50 p. m. January 25, 12:25 p. m. January 26, 8:37 p. m. January 28, and 5:52 a. m. February 1, the latter stronger than the others and from an origin farther from the Observatory. The teleseism was at 11:09 a. m. (H. S. T.), Wednesday, January 30, 1918, from an origin at least 4300 miles from the Observatory. Microseisms increased slightly January 27 and have decreased to rather feeble vibrations since. Volcanic vibration increased in spasms January 31-February 1. Motion of tilt increased strongly south and moderately west the early part of the week, with vigorous recovery north and east January 29-31, followed by southwest tilt again on February 1.

Very respectfully,
T. A. JAGGAR, JR.,
Director.

THE INDEX OF DANGER FROM VOLCANOES.

Lecture to Associate Engineers of Hawaii, Hilo, Jan. 16, 1918, by T. A. Jaggar.

When I was asked to speak on this subject I was given a large order. To know the index of danger means to know the subject more thoroughly than anyone has yet accomplished. The topic is an interesting one, however, and within the range of a brief discussion if my hearers will understand by it the indications which volcanoes in certain moods yield as premonitory symptoms of an outbreak dangerous to human beings. I do not understand the subject to include index of danger from earthquakes, nor can I include here a discussion of means of preventing disasters. This I must leave for the present to you engineers.

The index of danger is not quite identical with the index of eruption. For there may be great eruptions without any danger, like those on the summit of Mauna Loa, and there may be great danger from a volcano without any eruption, as in the case of the terrific earthquake on Epomeo volcano in Ischia in 1883. This was believed to be strictly volcanic, an abortive effort on the part of an internal lava column, wedging upward in a fissure which suddenly yielded without, however, releasing the volcanic fluids. The responsibility placed on an observer, therefore, to predict danger demands first foreknowledge of explosive, effusive or abortive eruption, and secondly the effect of the phenomenon on humanity.

With this preamble, and having in mind our Hawaiian volcanoes in particular, let us examine the meaning of danger, and then the expectancy of danger for Hawaii.

Danger means

(1) Explosion and suffocation, des-

truction by burial of houses under sand and stones, destruction by tornado blasts from a crater, or loss of life by direct bombardment from flying or falling stones. Falling in of roofs may be occasioned by gradual accumulation of dust or sand at some distance from the volcano.

(2) Outrush of lava from old or new crater vents, destruction of lands, houses, roads, tanks, fences, cattle, pigs, horses or men by trapping between two converging lava flows, by direct overwhelming of lava flows rapidly or by slow overwhelming through months of pushing lava. Lava flow is rarely a source of loss of life. Secondary disaster may be caused by forest fire, by damming or drying up of water-supply or by blocking of indispensable highways such as railroads.

(3) Earthquake accompanying eruption, great shocks sometimes occurring just before or during a volcanic outbreak. Falling masonry, land or mud slides, falling rocks from cliffs, wreckage from gradually increasing small shocks which have weakened buildings —all the usual earthquake effects may take place in such volcanic earthquakes just as in any other shocks, destroying life and property.

(4) Tidal waves, that is, great shock waves forced up in the sea, either through an earthquake under the sea bottom, through a volcanic convulsion in the sea bottom like a sudden explosion, or through a volcanic blast downward to the shore from a crater on the land which pushes the water away from the strand and so causes a back-wave which washes the shore disastrously. Tidal waves are worst on a shelving flat shore like Hilo bay, but they may happen on a steep off-shore bottom like Puna or Kona if earthquake faults on the land coöperate by actually depressing the land a few feet, and so drown permanently a stretch of shore. This happened on the Puna shore in 1868.

Hawaii has had **Class 1, explosion and volcanic blast,** in 1790, from Kilauea crater, when the soldiers of Keoua and their families and cattle were suffocated and burned. A repetition of that event would probably wreck the Volcano and Crater Hotels, the settlement at 29-miles, the military camp and Ainahou, the government road from west of Uwekahuna to about 26-miles, the crater road, and destroy timber and water tanks for a radius approximately six miles from Halemaumau in all directions. According to the wind direction at the time the damage would extend farther to leeward than to windward. Fine sand would fall at Glenwood, and dust would fall at Hilo during winter weather of calms and southerly winds. During trade winds the heavy ash falls would be in the Kau direction. The damage at 29-miles would probably be much less if the trade wind from east-northeast were blowing strongly. If it were really a great eruption the ash might fall on Maui and Oahu.

This Territory has had **Class 2, lava flow,** as the common and invariable accompaniment of the greater outbursts of Mauna Loa, Kilauea, Hualalai and Haleakala for hundreds of years past. The flows have run from five to sixty miles, have burst out far inland or near the sea or under the sea, have built out shorelines, and have destroyed lands, houses, roads, forests and filled river beds. The last land flow from Kilauea was in 1894 in the crater; the last from Mauna Loa was in 1916 in Kahuku and Honomalino. The last flow to break out on Kilauea mountain away from the crater was in 1868, rising through cracks in the Kau desert.

The same line of cracks extends past the crater towards the east point of the island crossing the Hilo road at about 8-miles, in the jungle to the north of the Olaa mill. There is at this moment a tremendous gas-and-lava pressure in Halemaumau, a pit at the summit of a flat inner cone or slag heap within Kilauea crater. Considered as an expansive fluid filling cracks, the apex of this lava column (the central crag) is now 30 feet above the rim of Halemaumau, 260 feet above the foot of the trail where it strikes the lava below the Volcano House, 600 feet above the bottom of Kilauea Iki and some 3400 feet above the rift line at 8-miles. A sudden release along the rift northeastward instead of southwestward as in 1868, would produce a series of Hilo earthquakes and a lava flood in the Olaa direction. 1840 produced just this effect on another rift line, namely Kapoho, and as lava floods at various places from Makaopuhi to the east-

northeast, some of which reached the sea. Flows from Mauna Loa have twice threatened Hilo in the last seventy years and the 1881 flow reached and diverted the Waialama River in Waiakea, and gulches formerly filled with water were filled with a fiery flood described by Coan as moving half a mile a day. The 1855 flow poured into the upper Wailuku River and stopped five and a half miles from Hilo.

Hawaii has had **Class 3, earthquakes,** as the accompaniment of its eruptions. They have usually been numerous and small. In 1868 they were numerous and large, both on Kilauea and on Mauna Loa, with lava flows from both volcanoes. They were terrific in Kau, accompanied at Kapapala by a destructive landslide and along the coast by a tidal wave. A repetition now of that disaster would do serious damage at Kapapala, Pahala, Hilea, Honuapo, Naalehu and Waiohinu, on the new stretch of road west of Waiohinu and possibly to the hotel buildings at Kilauea. As before, the shore villages from Punaluu eastward would suffer from both earthquake and wave. Moreover the next terrific earthquake on Hawaii is not likely to be at the same place as the last one.

Hawaii has had **Class 4, tidal waves,** principally in the 1868 crisis just mentioned, but also at other times damaging Hilo and Kahului.

In considering the menace of volcanic disaster, then, there is no reason whatever to consider this Territory immune. The little ninety years since Dibble wrote the first Hawaiian history is much too short a time for volcano statistics, for the common intervals between great crisis are in multiples of sixty-five years, as has recently been shown by Omori for Asama volcano in Japan. One hundred and thirty years is a common interval between great cataclysms at the same place. This was the period since the last catastrophe by earthquake at Messina, and by eruption and earthquake at Kagoshima, Japan. 1920 will be sixty-five years since the tremendous activity of 1855 for both Kilauea and Mauna Loa. 1920 will be one hundred and thirty years since Kilauea exploded and threw out all the great rocks which one sees near Keanakakoi, and destroyed Keoua's warriors. And we know nothing of the duration of that series of explosions, nor of the lava flows and earthquakes of the period, nor of the activity of Mauna Loa. If 1868 was frightful, and involved both volcanoes, it is probable that 1790 was much worse. It is quite possible that Hualalai and Haleakala partook of that period of activity, for Hualalai was active ten years later and Haleakala hal lava flows at the south point of Maui at some time during the experience of natives who were still living when the first missionaries came here.

I do not pretend to predict anything portentous for the year 1920, but merely call attention to the sequence, the 65-year cycle having interested us at Kilauea because of agreement with theoretical considerations based on astronomic control, as discussed in Mr. Wood's paper on cyclical variations of Kilauea activity, the Second Report of the Observatory.

The commonly cited indications of coming eruption, as summarized by Mercalli, the famous director of the Vesuvian Observatory, are as follows:

(1) Earthquakes and tremors.
(2) Elevation of the land and retirement of the sea.
(3) Subterranean noises.
(4) Rise of crater floor (the top of the lava column).
(5) Rise of temperature at vents.
(6) Increased or changed gases at fumaroles.
(7) Drying up of water.

There are not mentioned in this list three other extremely important indications, which here in Hawaii are of prime significance; namely:

(8) Interval since last eruption.
(9) Nature of action at contiguous craters.
(10) Preliminary crater eruptions antecedent by some years to final lava flow eruptions.

On examining this list in the light of experience here, we may leave aside for the present noises and temperature change, gas changes and dessication. Rearranging, we have left a list of subjects of great interest because they are all related and go to the heart of the matter, namely the lava column.

(1) Interval since last eruption.

(2) Sequence of action at nearby craters.

(3) Elevation or tilting of the land.

(4) Sequence of tremors or numbers and intensities of local earthquakes.

(6) Preliminary crater eruptions.

I cannot do more today than illustrate these briefly as applied to Mauna Loa. I believe that the principles involved are fundamental and apply to any volcanic system. By volcanic system I mean an underground group of fissures charged with lava, an individual volcano being a more or less haphazard pile of slag.

The interval since last eruption is a useful index the more we know of cycles for any particular volcanic rift. This is intimately tied up with the second subject, the action at nearby craters, for the cycle in Hawaii, for instance, includes not Mauna Loa alone, but the Mauna Loa-Kilauea system. Inspection of the chart showing the movements of Kilauea lava while Mauna Loa was erupting in 1914-16 shows that Kilauea at each Mauna Loa spasm spurted and fell, the spurt being higher and the fall lower each time, until when Mauna Loa ceased activity the lava came over to the Kilauea pit and rose to a high level and stayed there.

Such a sequence in three years typifies what may be expected of the longer-term successions The Hawaiian lava column escapes to make a lava flow nowadays about once in nine years. This 1914-16 happening was an incident of that larger succession. In like manner about once in say sixty-five years a great crisis occurs, perhaps at the end of a group of incidents which occupy fifteen years or more. Thus the 1868 crisis here culminated sixteen years of unparalleled activity in both Kilauea and Mauna Loa, with immense lava floods 1852, 1855, 1859, 1868. The 1790 crisis may have accompanied a similar prolonged activity but we have no records. And on a still longer term scale there may be still bigger events which afflict the Hawaiian Islands at intervals of centuries. The shorter intervals appear closely connected with solar control and have already been used successfully here for prediction.

The sequences in dimension and distance are frequently progressive like those in time. The 1843 flow stopped twenty-five miles from Hilo, the 1852 flow stopped 12 miles from Hilo, the 1855 flow five and a half miles from Hilo, and the 1881 flow one mile from Hilo. All emerged from the same general rift line. From 1868 to 1907 there was alternation of flows first north, then south, for each eruption, and the 1916 flow broke the sequence. The 1916 flow should have had a north vent. In 1907 and 1916, two flows in succession poured out on the south side. The north flows since 1852 have been increasingly voluminous, excepting 1899; the 1916 flow was not voluminous and the high pressure at Kilauea in 1917 and at present, unequalled since 1894, attests an incompletely relieved lava column. If a new flow on the north rift should break out near the 1852 vent, which was low, Hilo would be seriously menaced, particularly as the older flows would act as confining ridges on each side.

The question of tilting of the land is tied up with the rise of the crater floor. I have recently shown that we must consider the lava column to be a hard elastic body under great tension from gases in solution. Release pressure and the gases escape, generating heat thereby and liquefying the lava. The underground column is a slow-moving affair which, however, once in so often must expand the containing fissure to the limit of gas release. This is an eruption. The upward swelling in the fissure system may be expected to actually arch the island. Hence it has been with the keenest interest that I have watched the seismographs at Kilauea crater recording an enormous variation in the vertical, an actual plumbline shift of ten seconds of arc in the course of a few days, and still more in a permanent set of the ground in the course of months. A tidal movement of **eight-tenths of a second** is considered exceptionally large elsewhere. In general the tilt has been to the west and south during sinking lava in Halemaumau, and to the east and north during rising. The pit is southwest of the Observatory, but the dominant tilts have east and west—towards or away from Mauna Loa. With and before the Mauna Loa eruptions there were strong east tilts and after them there were west tilts. The strong east tilt in 1914 began a week before Mokuaweoweo

broke out. The quantitative relation of these tilts to the measured rise and fall of the lava promises important results which may enable us anywhere to locate and time the movements of lava underground. The fact that great movements of elevation before eruption and of depression after eruption in Italian and Japanese volcanoes have been verified geodetically beyond question, lends support to the seismometric data.

I have little time to take up volcanic tremors and local earthquakes. Suffice it to say that extraordinary short-period tremors are going on all the time at Kilauea and vary in intensity. Local earthquakes increased to an enormous maximum during the lava flow period of 1916 and the 1914 outbreak of November-December was heralded by seismic spasms of thirty-four shocks in July, more in September and seventy-four in November, falling off to normal (thirteen) for December after the gas pressure was released.

With regard to rise of the crater floors and premonitory crater eruptions, these are familiar happenings in Hawaii. A monumental rise of the Halemaumau floor is now in progress with the lava towering above the edge of the pit. The Kilauea sequence since Mauna Loa became sealed suggests strongly that the lava column is expanding on this side of the system and if it follows its habit it will rise and fall in Kilauea for two or three years more, then sink away and rise to a summit eruption in Mauna Loa. This will be followed by a flank eruption two or three years later. Such was the sequence in 1896-99, 1903-07, 1914-16. The next Mokuaweoweo outbreak ought to come about 1923, followed by lava flow before 1926. It will be seen that the word "eruption" means a complicated formula when two or more vents are involved.

In conclusion I might touch upon the use to which a knowledge of the "index of danger" may be put. You will see from what I have said that the subject is dependent, like insurance, on the cyclical or statistical treatment. We need observatories in Guatemala to discover the Guatemala cycles, as distinct from the Hawaiian cycles. A volcano is a vent for something accumulating, and is regular according to rate of accumulation. Great luni-solar stresses act as trigger, but the particular district has the secret of its index equation awaiting the measurements of the investigator. Widespread use of the "index of danger" can only be made when charts and tabulations have been collected for many districts and these districts arranged in orderly series showing a common origin. That has now been done for the winds and tides and movements of the stars so that we easily predict hurricanes and neap tides and comets. The inner earth would seem to be as worthy a subject, when you consider that there are at least two great volcanic disasters a year, and once in two years a city is utterly destroyed as has just been demonstrated at Guatemala. Two years before 30,000 people were killed at Avezzano in central taly. The year before 22,000 were made homeless at Sakurajima. And in 1908 130,000 were killed in Messina in five minutes, at the base of Etna volcano.

Summary.

To summarize the index of danger for Hawaii, the following puts the matter categorically, but does not pretend to be accurate or complete. It suggests the lines of reasoning based on an all too limited experience. There is here treated, in order, **Time** or expectancy, **Intensity** as marked by symptoms, **Place** as concerning danger.

TIME.

I. A great eruptive period may occur every 130 years, may affect several volcanoes together, may last 10 years or more; — Kilauea - Hualalai 1790 - 1801 (probably Mauna Loa and Haleakala also).

II. Secondary eruptive period at the half-interval 65 years, of long duration with great lava floods. Kilauea-Mauna Loa 1840-1868.

II. Accumulation and discharge once in nine years; alternation Kilauea and Mauna Loa; alternation Mauna Loa lava-flows north and south; periods of culmination in each crater about three years.

Intervals since 1868 slowly increased, volume of discharge decreased, both craters have built up their floors and confined the lava column, present condition shows high gas pressure as though a crisis were approaching.

INTENSITY, Localized Symptoms.

For the great eruptive periods,

I. A high closed dome is likely to be constructed over Halemaumau (1850).

II. Prolonged elevation or swelling of the island measurable instrumentally probably takes place. A tilting of the ground away from the center sets in for years.

III. The crater floors progressively rise.

IV. Local earthquakes increase in temporary swarms.

V. Lava gas escapes with decreased freedom at the inner craters, possibly causing decrease of volcanic tremor recorded instrumentally.

For Individual Eruptions.

I. Kilauea lava sinking slowly, portends coming eruption of Mauna Loa.

II. Earthquake spasms on Mauna Loa follow this and increase, especially at equinox. Kilauea lava spurts up with these spasms.

III. Sharp sudden tilt away from Mokuaweoweo near solstice suggests that the summit crater will erupt in a few days.

IV. At beginning of Mokuaweoweo outbreak, seismographs show unusual motions of fling. Gas-lava fountains for some months at Mokuaweoweo, lava floods there, Kilauea spurts up and subsides in sympathy. As eruption dies away, tilt is temporarily toward the center (the tilt away recovers somewhat). This is the preliminary eruption.

V. Kilauea lava rises, equinoxial earthquake spasms continue, Mauna Loa quiet one to three years. Persistent set of tilt away from Mauna Loa, and in detail possibly **away from the flank where the lava is to flow.**

VI. Explosion near summit Mauna Loa on rift which is to yield lava flow. Excessive tilt suddenly, swarms of earthquakes where lava is to come out, lava wells up and flows out flank rift.

VII. When a crisis is indicated for other reasons, the earth strain as **equinox** approaches favors earthquakes, and as **solstice** approaches favors eruption.

VIII. After Mauna Loa flow, Kilauea rises for about four or five years.

PLACE as to Danger.

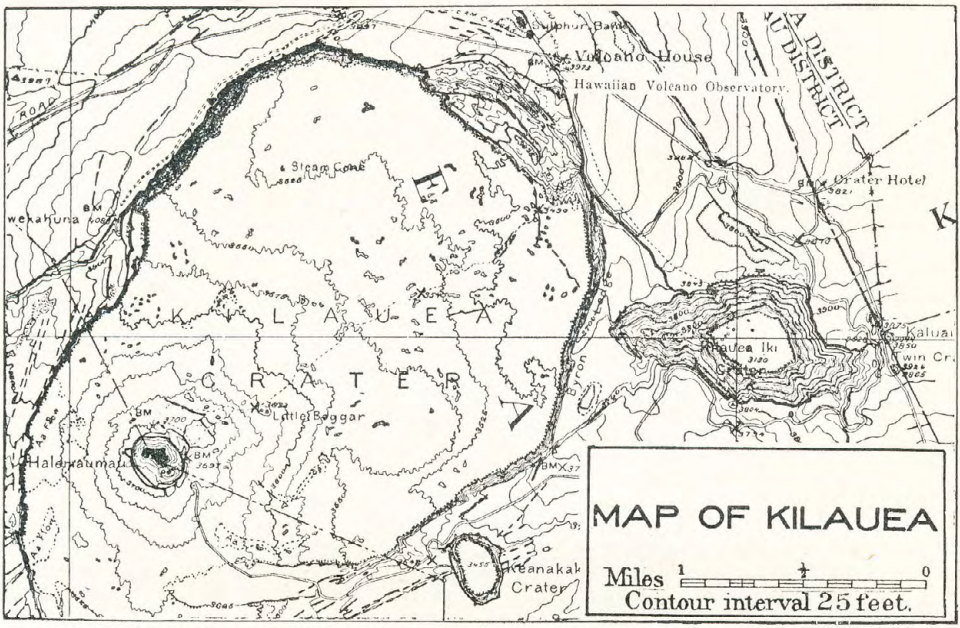
I. Expectancy of alternation makes Kilauea or Mauna Loa, respectively, more dangerous.

II. It takes the north or south rifts of Mauna Loa, respectively, more dangerous. Danger to Hilo-Hamakua north to Kona-Kau, south.

III. Coming flow promises a localized center for earthquakes, either in spasms for a long period, or in sudden increase for an immediate crisis. The locality would be Puna, Olaa or the Kau desert for a Kilauea lava-flow; the upper Wailuku, Puu Oo or Humuula for a Hilo lava-flow; Hilea for a Kau lava-flow.

IV. To localize the place of maximum danger, the most hopeful line of investigation is to determine exactly the centers of radical tilt and local earthquakes.

This could be done by having volunteer observers operate small ink-recording plumb-bob pendulums, equipped with magnifying levers. Such instruments could be made of about the size and cost of a thermograph, say for $35. The observatory would be glad to design and have made such instruments, the principles of which have already been experimented with at Kilauea. If placed at Puu Oo, Puu Lehua and Ainahou for the north flank and at Kapapala, Hilea, Kahuku Ranch and Honomalino Ranch for the south flank, it ought to be possible to determine in advance whether the next lava-flow from Mauna Loa were coming from the north or from the south, and to locate the center.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

		Expressed by accelerations measured in millimeters per second per second.	
I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit, **the milligal.** The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here **defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.**

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, FEBRUARY, 1918. No. 2

Volcano House, Feb. 9, 1918.

During the week ending Friday, February 8, 1918, the lava lakes of the Kilauea inner pit first subsided a few feet and then recovered and at the end of the week the crags appeared slightly higher. As a whole, the tendency of the week has been a stationary condition, with the liquid lava about 40 feet below the rim of the pit.

On Saturday, February 2, at 2:30 p. m., the lake was slightly below the inner floor at the east cove, grotto fountaining was vigorous in the southeast cove, and the streaming thither through the southeast arm was rapid. The small central pond was crusted over with a glowing crack in the crusts. At 3:20 p. m. the southwest pond was level with its bordering bench and showed the usual fountaining at the south tunnel corner, where the blowing cone puffed and occasionally ejected spurts of glowing lava. There had been fresh slides on the southwest sides of the central crags, and at 6 p. m. these could be heard in motion. The movement of the southeast crag overturning northward was still in progress, for at this time there was another fall of rock from its north side into the lake.

On February 3 at 2 p. m. the inner bench was two feet high and there was an active grotto on the east side of the southeast crag. The small central pond no longer showed glow. At 2:15 p. m. the southwest pond had risen so as to overflow the crust at the entrance to the south tunnel, and the blowing cone was noisy.

On February 4 at 2:15 p. m. the lake was depressed about 4 feet below the marginal bench, the southeast arm was crusted over, but there was the usual activity in the southeast cove. The small central pond resumed activity and exhibited one fountain. At 3 p. m. the southwest pond showed central and border fountains four feet below the margin, and there was the usual activity and puffing at the south tunnel grotto and blowing cone.

On February 5, 1918, at 2:30 p. m., the lake was relatively still lower as compared with the east cove bench, which was 6 feet high. The inner shelf of recent overflow southeast was about 20 feet above the southeast channel. Slow rising appeared to be in progress. At the southwest pond the inner bench appeared 9 feet high, the pond was crusted and showed only two places of boiling, and the fumes were thick. At 5 p. m. there had evidently been subsidence, for the inner bench at the southeast cove was 10 feet high, the streaming was swift and the bombardment strong.

On February 6 at 2 p. m. the lake was so low that the southeast shelf stood fully 30 feet above it, and there was swift streaming and vigorous fountaining. There was a slight rise from 2 to 3 p. m., followed by a sinking spell, when the surface subsided about two feet, and this was followed by a very quiet interval of crusting over.

Inspection of the north lake from the inner cliff above it at 4 p. m. showed that there were two islands standing three feet above the molten lava and a peninsula attached to the east island mass so as to develop a wide floor surface there. The open channel was about 60 feet wide. There were a number of fountains and much smoke.

On February 7 at 2 p. m. the inner bench at the southeast cove was 6 feet above the lake, which was everywhere quiet and crusted. The southwest pond was in the same condition, with only the

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Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

south tunnel grotto rumbling. Much of the west cone had collapsed, and much smoke rose from the west cone ridge.

On Friday, February 8, 1918, at 2:30 p. m., conditions were little changed and the inner bench appeared 10 feet high. There were border fountains in the southeast cove and others in the channel leading to it, and numerous fountains migrated from the north lake southeastward. At 3 p. m., however, a sharp rise set in, so that in half an hour the height of the inner bench was reduced to less than six feet, and at 5:10 p. m. the inner bench at the east cove was overflowed in the region of the tunnel grotto there.

During the week ending at 2 p. m., Friday, February 8, 1918, the seismographs of the Whitney Laboratory registered a local earthquake at 1:34 a. m. on February 4, and spasms of volcanic vibration were strong on February 5-6. During the same interval, February 4-6, there was marked tilt to the north and east; otherwise the position of the recording pens during the week indicated tilt dominantly south and moderately or only slightly east. Microseisms were moderate, showing some increase during the vibration period above mentioned.

Volcano House, Feb. 16, 1918.

During the week ending Friday, February 15, 1918, rising of the lava of Halemaumau has increased so as to overflow the flood level bench of January 24 southeast and finally to flood the great northeast valley so voluminously that half of the 1894 bench and the valley back of it have become submerged and a new flat floor extends thence all the way to the north pit and beyond. A remarkable feature of this filling was that the lava welled up through the bottom of the 1894 depression instead of overflowing the lake margin. Other overflows have poured from the northwest pond chasm to make new fillings under the west shelf. Following these flows there have been the usual uplifts of the crags, which are now at their highest. The northeast fill, however, is still far below the level of the lake, and the latter remains as in January, about 25 feet below the rim of the pit.

On Saturday, February 9, at 2 p. m., the lake was six feet below the inner bench, streaming southeastward was swift, and there was strong fountaining in a large grotto on the south side of the southeast crag. From 2:30 to 5 p. m. rising was pronounced, so that the liquid lava nearly reached the upper surface of the inner bench. There was much tumbling of spatter margins into the lake along its eastern shores.

On February 10 at 2 p. m. the inner bench was 10 feet high and streaming and fountaining were vigorous. At 4 p. m. there had been a rise strong enough to flood the bench at the southeast tunnel. The only fountain was in the grotto under the southeast crag on its south side. At 5:30 p. m. there was collapse of the southeast crag bench and of the southeast point, into the lake, during subsidence.

Measurement on Tuesday, February 12, at 11 a. m., made the depression of the lake below the east rim of Halemaumau 33 feet. The central crag was 45 feet above the rim, and the east ledge 16 feet above it. These data showed that the lake had risen 11 feet in 11 days, or about one foot per day as an average, but the two crags were each a foot lower than on February 1.

On this day at 11 a. m. the lake was very high and rising, reaching nearly the general level of the southeast shelf of January, and at noon overflowing somewhat into the crevasses south and through the gateway leading to the central pond. The rising was marked by advancing waves of over-riding layers of the incandescent melt moving forward from the west through the southeast arm. The lake was largely crusted over, but there was bombardment at the east cove and southeast tunnel, at the east end of the

southwest pond, at a high dome grotto under the north smoke cliff and occasionally at the east gulch and various points northwest and west. A high spatter rampart had been built above the southeast tunnel, and a rampart at the east end of the southwest pond had extended the floor there so much westward as to greatly shorten the pond. Streaming in the southwest pond was eastward to this rampart.

The noon rise was pronounced and threatened to flood the pit of the cenеral pond, which was at a much lower level than the southeast cove lava. At the central cove and the east cove there was strong overflowing, and all the islands and marginal plains about the north lake were drowned except the larger northwest island. The two eastern pinnacles of the west crag mass were left standing as islands. The northwest chasm under the driblet cone was filled with a pond of liquid lava at least 150 feet long, and this had been recently overflowing, along the chasm as a river bed, to the lake and it had also spilled over the lip of the chasm northwestward. At 12:15 p. m. the main flow of the day, to satisfy the noon rise, poured from this northwest pond westward to the depression at the base of the west shelf, where the flood forked right and left and then pooled in this shallow valley, the pool extending all the way to the pinnacles at the base of the northwest crag. The flow was still pouring like a river into this hollow at 1 p. m.

In this rise the lake was gaining on the crags, the southeast crag and the western and east island masses showing tendency to partial submergence. The crags showed no marked rising, and the only sliding rocks were at the east gulch. The remarkable poised block which stood erect against the summit mass of the central crag, but separated from it on its south side by a great crevasse, was seen from the west to be the top of a slab parting from the central crag mass along the east-west fissure, which sloped downward to the north at an angle of about 80°. Under the west station there were fresh falls of rock from the wall. The fumes were not especially thin.

On February 14 at 3:30 p. m. the lake was brimming level with the southeast shelf, and a fresh broad overflow from it of rough aspect had poured across the southern part of that shelf. There was high gas pressure, border fountains were numerous, streaming was rapid through the southeast arm, and new ramparts had been built southeast, east, and at the central cove. The east island and the southeast crag had been rising. At the time of its overflow the lake had been about 25 feet below the southeast station; at 4 p. m. it was a foot lower. A fresh flow had poured from the northwest pond again to the base of the west shelf, and was still glowing. At 5 p. m. there was more overflowing southeast. There had been fresh overflows also from the margin of the southwest pond, which was now again level with its bank, and crusted over. A new west cone had been built, tapering to a slender pipe above, fully 15 feet high, and on the east side of the former cone.

On Friday, February 15, 1918, in the morning, the period of high pressure reached a culmination by breaking a subterranean way for the lava through the cracks which separated the sunken crescent-shaped northeast bench of 1894 from the outer northeast wall of Halemaumau. Here the liquid melt welled up along a line following the bottom of the depression which for twenty-four years has been almost unchanged. By noon a great oblong pond filled this depression, and from it, over the eastern end of the 1894 ledge, a glowing cascade 10 to 15 feet wide poured continuously down the slope 20 feet to the northeast valley below. Here the lava pooled, and both pools kept spreading and rising all day long, the lower one gradually gaining on the upper until they came to a common level. The total filling of the northeast valley was fully 20 feet of depth, and the length of the ponded area a thousand feet. The action was extraordinarily quiet. Over the feeding fissure in the upper pond were four small driblet cones on the crust of the pond and an open pot bubbling in artesian fashion as a perpetual fountain, the westernmost of the row. This line of cones was near the wall and directly under the northeast station. The ponds remained crusted except for occasional cracking up and foundering of the crusts. Around the margins dribbling flows pushed out, making curtains, ropes and festoons of their sur-

face skins, and new trickle flows perpetually pushed among the rocks. The cascade poured from under a ragged edge of crust of the upper pond into a swirling cauldron margined by the crust of the lower pond. At noon the surface of the lower pond showed the pattern of a festooned jumble of flows, but later in the day this crust sank into the melt beneath, leaving a smooth surface. The final result was a smooth floor of large angular units bounded by cracks like the floor of Keanakakoi crater. The only noises were the hissing and fountaining at the inlet vents and the steady rush of the cascade. The former emitted an odor of sulphurous acid, but the dominant smell was like a foundry. At 5:30 p. m. the great flood was still rising, but the two ponds had almost joined and the cascade was reduced to a torrent of slight fall. A pasty blowing cone had formed under the east station. The fill had extended to the north pit well beyond the north station, and the marginal flows were there still progressing northwestward. Only two puffing and flaming cones remained of the five feeding vents. A sudden cracking and foundering throughout the upper pond about 7 p. m. was accompanied by very bright incandescence, violent bubble fountaining, rapid spread of the action over the whole surface so as to engulf huge slabs of crust, and the cones disappeared, leaving sluggish fountains in their place. Intense heat and sulphur fume was emitted, and there was left a smooth cherry-red lake which hardened again quickly. Similar but more sluggish breaking-up happened in the lower pond. At 7:30 p. m. the northeast fill was still rising, and at least 30 feet below the lake level.

Throughout this performance the main lake remained 4 to 6 feet below the shelf-level southeast. An additional rise the previous night had extended the fresh lava on the shelf eastward to the east gulch, and had poured through the southeast gateway and filled the depression of the central pond. In the evening the lake was slightly higher than at noon, depressed three to four feet below the bench, streaming southeastward as usual, and fountaining with high spurts from the southeast crag grotto. There was a very hot tunnel grotto surmounted by a glow-cone under the central pond gate, and fountaining could be seen in that pond. The north lake and southwest pond also exhibited border fountains. During subsidence at 7:15 p. m. a red-hot margin three feet deep was revealed all around the lake, with stringy drip curtains. Large central fountains migrated southeastward, with very high fling of spray.

A small glowing pudding of lava had emerged on the south floor from a crevasse leading to the central pond. An active flow from the new west cone had filled the west pit and sent another fork eastward 50 feet. The top of the west cone was 20 feet above its base and was only about nine inches in diameter, recurved at a right angle like a bent pipe, with a fringe of stalactites hanging from the end. There was a glowing fissure at the base of the northwest cone. The recent filling of the northwest depression had been followed by more uplift of the northwest inner cliff over the lake and of the broken peaks under the northwest crag. These were now elevated and separated by a smoking chasm from the northwest crag, and beyond would be heard a rumbling lake grotto.

During the week ending at 2 p. m., Friday, February 15, the seismographs of the Whitney Laboratory have registered no earthquakes. Microseisms became strong on February 9 and decreased thereafter. Volcanic vibration increased spasmodically February 10-12 and decreased thereafter. At the same time there was an increase of tilt very strongly to the east and somewhat northward, followed by a steady decline of the east tilt for three days and a rapid increase of tilt to the south. The week has been stormy, with much rain.

Volcano House, Feb. 23, 1918.

During the week ending Friday, February 22, 1918, the lava column of Halemaumau has made a remarkable spurt in its rising, so that the lake surface at the end of the period had reached the level of the rim of the pit southeast and the overflows there were only a few inches below that rim. The imminence of overflow on that side became almost a certainty as the floods across the southeast bench dammed themselves back by congealing in the east and west gulches and so were unable to escape freely to

the wall valleys northeast and southwest. At the same time much rising in the western and northeastern wall valleys took place, chiefly by welling up at the northwest chasm and around the wall fissures. The crags also rose higher than ever before. All of this culminated early Saturday morning, February 23, in an overflow of Halemaumau southeastward, destroying the road terminus.

On Saturday, February 16, 1918, at noon, the previously described upwelling in the northeast valleys continued. The lake was about four feet below the southeast bench, with the usual streaming and border fountains and much overhang showing stalactites. The southwest pond was broken up and at 1 p. m. showed border fountains, overhang and temporary subsidence. There was no flowing from the west cone. The northeast valleys showed red-hot cracks in smooth level floors about 30 feet below the lake level and flush with the eastern and middle parts of the 1894 ledge, which was submerged at those places. The two valleys were now at a common level, and the five vents were marked only by stained and smoking spots, one of which at the east was hissing, while the larger western one was a small low cone. The margins of this new floor showed trickle flows, and the north pit was now entirely filled with lumpy pahoehoe lava.

The long northeastern crag escarpment was higher and more tilted, showed a swollen bench of uplift at the southeast base of the east ledge, and here rocks were falling as though the middle part of the great scarp was swelling up. The east island mass showed increased uplift toward the center of the pit where the inner spatter margin at the lake shore was 10 feet high and sloped down toward the east cove. The southeast crag profile again showed five benches, the two upper earlier ones being tilted west, while the three lower ones of later date were tilted north.

On this day began a severe southerly rain and wind storm which threatened on February 17 to wreck the Observatory as in 1916 and destroyed roofing at the Volcano House. The week ending February 20 produced 35.72 inches of rain, the maximum being reached on February 19, with nearly 14 inches in one day.

On February 18 the lake was rising about three feet between 3 and 5:30 p. m., reaching a level one foot below the southeast bench. Activity was moderate, streaming fairly rapid, with glow lines between crusts; occasional high spraying central fountains would develop, there were large spatter domes southeast and northwest, and a new shore point protruded toward the center of the lake from the east island mass. The lake was still, however, some 25 feet below the rim.

Remarkable on this day was the pronounced uplift everywhere by intumescence. The lower bench of the southeast crag was lifted ten feet. Lifting was apparent at the edge of the southwest pond, the west cone ridge and the northwest inner cliff, all approaching the level of the Halemaumau verge. At two places the inner shelves of 1917, namely northwest and south, were uplifted bodily. The lava of the southwest pond was eight feet below the marginal rampart, the latter having been lifted along with the central crags, both of which were changed. The northeast scarp was higher, the northwest cone had fallen, and the north pit had slumped. The central pond was larger. Everything suggested that the entire lake basin along with its bottom had been lifted bodily.

The swelling effect extended even to the new northeast floors, which were much arched and higher. Little of the 1894 ledge protruded. The cone vent loudly hissed, a driblet heap over a crack in swollen up slabs. Along the crack were small driblet blowing pipes. This floor was now 20 feet below the lake level.

On February 20 at 11 a. m. the relative level of lake to bench appeared the same. Crusts were heavy, the southeast cove appeared larger and there was fresh overflow through the east gulch. Lava was welling up through the wall crack under the south station, and this crack was extending itself westward and producing fresh falls of rock. The crags were all higher and steeper, the east ledge tumbling to pinnacles. The northeast fill was still higher, and the hissing at the vents was less, giving off the odor of pure sulphur vapor. There were slight flows in the afternoon, but up to midnight there was no marked change of

level in the lake, which remained 20 feet below the rim of Halemaumau.

On February 21 at 2:30 p. m. it was evident that a rising of the morning or at noon had been extraordinary. Floods from the southeast arm had so built up the bench under the southeast station that the hot crusted lava was only from 3 to 5 feet below the actual rim. It was possible that this was partly a mass uplift of the bench magma, including the bottom of the lake. At 3 p. m. the northwest chasm overflowed the west floor strongly for two hours, then the lake subsided seven feet. During this northwest flood its easternmost extension met a west-flowing stream from the northeast valley filling, on the north side of the northwest crag. At 5 p. m. and thereafter everything was flooding except the southwest valley. The southwest bench was 4 feet below the rim, covered with new flows which had poured both northward and westward. There was a flaming and blowing cone northeast and another in the west niche. The west shelf was nearly buried, and crusts were cracking and foundering. The north arm was mostly quiet, occasionally bright flaring was seen in the central region and southwest. The lake had that peculiar high pressure silent quality so distinctive of a great rise. About level with the rim of the pit the southeast lake rampart showed brimming lava carrying along tumultuous crusts, blisters and balloons of skin; noiseless fountains played in a shimmer of heat and the rampart was heaped with crusts. Voluminous overflows took place at 8 and 11 p. m., pouring west beyond the south station and north beyond the east station. The surface of these flows was finally, by measurement, only 15 inches below the rim of the pit near the southeast station, and the general level of the lake was above the rim level. Golden floods poured down the east gulch. There was a hot iron-carbon foundry smell. A bright curtained grotto gleamed under the south side of the southeast crag. Flames were numerous, bursting through crusts and balloons, a greenish flame played from a large cone at the central cove, there was a filagree cone at the east cove, there were flaming domes north, northwest, northeast, and in the northwest pond chasm, and sluggish lava was welling up below the south station, building a cone in the wall crack about 15 feet below the rim. The central pond was fountaining. The crags towered high, smoke was rather thin, and rocks fell from the east ledge and from the southeast crag. The lake was continually high until 11:45 p. m., when it subsided about a foot.

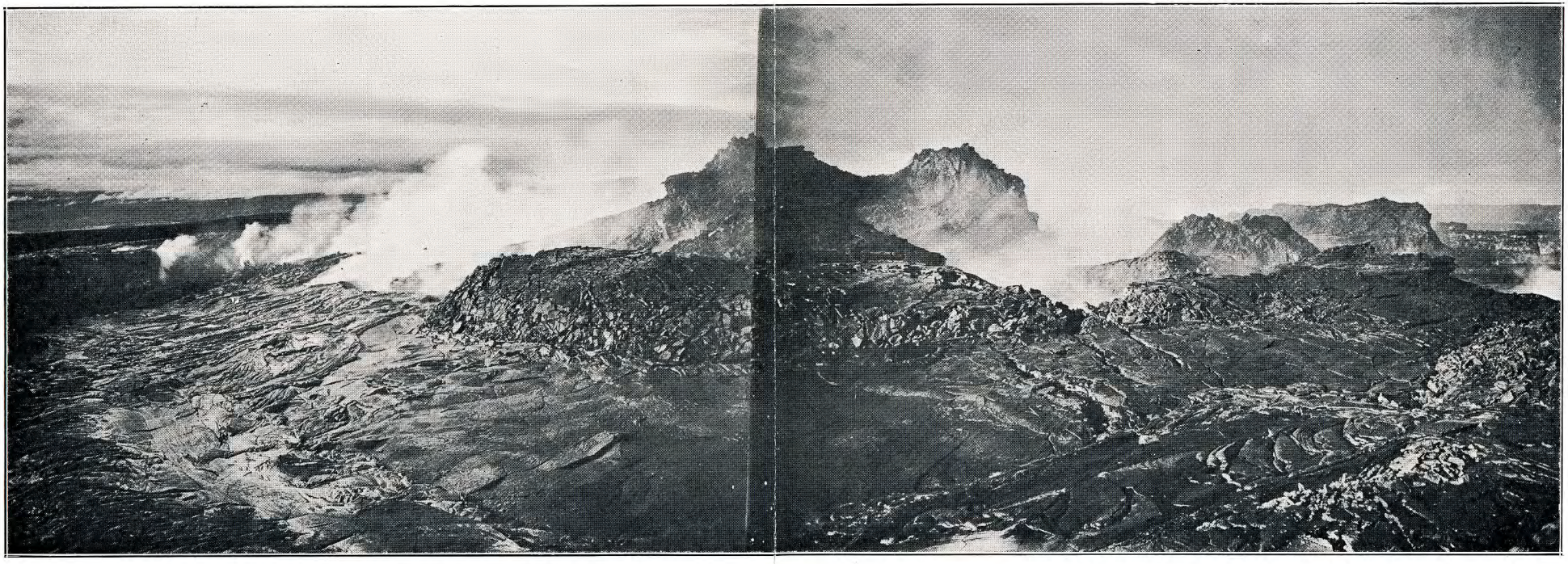
On Friday, February 22, 1918, conditions were much the same, but the flows of the southeast bench had sagged. The south wall crack produced flows spreading by driblets westward, and flows were spreading from the northwest fill eastward to the north pit. The lake fluctuated between short overflows and subsidences at about the rim level. A large double spatter cone had been built at the south corner of the southeast cove, and a bulging spatter margin surrounded the lake. Falls of rampart made waves in the lake, and streaming was swift southeastward. There were overflows at 1 and at 3 p. m. The lava pudding which rose from the wall crack south was capped with an arch of thick slabs which pulsated on either side of a crack extending 100 feet to the west, where hissing spiracles formed. The pit wall was still 30 to 40 feet high southwest, northwest and northeast. The northwest pond was fountaining, there was an active spatter dome in the west niche, there were large spatter domes in the north arm, the old west crag was a prominent tower, a cascade had poured from the north cove to the north pit, and the northeast floor was now only 15 feet below the northeast station, with a hissing spatter dome 10 feet in diameter, the counterpart of the one in the west niche. The crags were rising, as shown by rock falls under the north station, at the east ledge and at the northwest crag.

During the week ending at 2 p. m., February 22, the Whitney seismographs have recorded no definite earthquakes. During the storm, vibration was excessive and heavy microseisms followed it. East-west tilt has been slight, but tilt to the south has become excessive.

Volcano House, Mar. 2, 1918.

In order to understand the remarkable developments at Kilauea volcano during the week ending March 1, 1918, whereby

(1) The lava lake and bench of overflow, Jan. 24, 1918, from the southeast. Southeast cove and central pond gate on the left, southeast crag in middle with the central peaks behind it, east island crag and east ledge on the right.—*February, 1918.*



(2) Halemaumau, Jan. 24, 1918, from the south showing swelling up of floors and crags above edge of pit. Depression of lakes 27 feet. Crags 40 feet above edge of pit.—Photos. Jaggar. —*February, 1918.*

for the first time in twenty-four years the lake magma has overflowed the rim of the pit Halemaumau, a brief review is necessary.

In May, 1913, the Halemaumau lava sank to smoky depths over 600 feet down. In May, 1914, the measurements revealed about 600 feet of depth; May, 1915, 500 feet; May, 1916, 300 feet; May, 1917, 20 feet. This rise during four years was interrupted temporarily in 1916 by a fall and recovery coincident with the Mauna Loa outbreak. The remarkable rapidity of that recovery to the high level of May, 1917, would lead to the belief that May of 1918 should exhibit a still higher level provided no rupture released the Hawaiian lava column somewhere in a low-level flow, causing collapse of the Kilauea crater. Throughout 1917 the lava remained high; by January, 1918, the bench magma crags were far above the rim of the pit, and on January 23 the lake was again only 20 feet down. A subsidence followed, then rising was resumed.

The January high level accords with a seasonal fluctuation which I have come to consider systematic and related to the sun's declination. There is tendency for lava to rise suddenly at solstics and to sink suddenly at equinox. This movement is complicated, however, by a secondary one, possibly due, at the two seasons respectively, to gradual restraint and gradual release of gas pressure, whereby there arises after the equinoctial fall a prolonged rising, followed by a shorter fall to solstice; while from after the solstitial rise there is apt to be a subsidence followed by a pronounced rise to the moment of the equinoctial fall. The amount of the effect of each crisis will be dependent on the equilibrium of the lava column itself with reference to its general trend upward, downward or stationary through a term of years, and it is complicated also by the relation of stiff magma underground to liquid lava. The latter is a foaming product of release of gas pressure in the stiffer substance, and consequently there arises special chemical heating. The solar effect can hardly be other than a squeezing of the rock crust of the globe causing rise or fall of the stiffer magma in the cracks, this being the mobile substance next under the rock crust. It will hence be seen that we have to do with

(1) Magma in general escaping through the ages of volcanoes, perhaps expelled by pressure downward of the crust of the earth;

(2) This magma squeezed in or under the cracked crust of the globe by the stresses induced in the equatorial protuberance of the sun's northing and southing in summer and winter;

(3) Expansion of this magma by gases in solution, when released under such changing stresses;

(4) Transformation of this magma by gases escaping from solution to bubble form, whereby gas reactions generate heat, liquidity and a foaming circulation to make what is called liquid lava.

These four motive powers, the first two terrestrial, the last two resident in the lava itself, cannot fail to complicate a curve representing the rise and fall of a lava column through the centuries, the years, and the seasons. The net result for seven years past has been tendency to gradually rising lava in May and November, falling lava in June and December, sharp rising near June 20 and December 20; and a converse tendency to gradually falling lava in February and August, rising lava in March and September, sharp sinking near March 20 and September 20. It is this calendar which led the writer to watch with interest this year 1918 a falling off of the lava column after reaching the January 20-foot level; there was depression 40 to 50 feet below the rim from January 26 to February 8, with collapse and lowering of the crags to the middle of February and every evidence of subsidence.

Then came the pre-equinoctial rise and the evidence that it was to be extraordinary was the spurting up of liquid lava, beginning February 15, around the pit margins, in depressed areas, which have since filled quietly with large crescent-shaped outlying lakes. These are quite symmetrical, lying between the three great sector crag-masses and the outer wall, the sectors being lifted at the pit center, and the older lake occupies the three rifts ebtween the sectors. This arrangement undoubtedly means a doming of the bench magma carapace,

its rupture along three radial rifts and the welling up of the liquid lava through numerous shafts. The doming or intumescence of the hard floors of overflow has been the most remarkable feature of the last year, these being lifted into crags 90 feet high and more, and this hard substance has frequently risen faster than the lake so that the entire dish or saucer holding the lake has gone up bodily without any building by overflow. Recently this movement has been communicated to the outer wall of Halemaumau southwest, mashing up that margin by from 10 to 20 feet, as the swelling up of the central crags pinched the fresh fill of lava between them and the wall, and so displaced the wall.

On February 23, 1918, the lava lake overflowed the inner rim southeast at 4:55 a. m.; the outer rim, 5.09; the path from the automobile terminus was covered at 5:12; the automobile park was reached at 5:35; the park was covered at 5:41; and by 5:47 the walls surrounding it were buried. Ten minutes later it was estimated that the flow had traveled 400 yards. The total length from the edge of the pit is approximately a half mile east-southeast. By 8:30 a. m. the flow was slowing down. I am indebted to Mr. O. E. Long for the timing.

Overflows continued on this day with strong renewals about 1 and 6 p. m., and the lake was building high spatter domes, streaming eastward in both the southeast arm and the southwest pond, its rampart standing about 5 feet above the old rim of the pit, with spatter heaps 5 to 6 feet higher. The overflows buried the lip of Halemaumau from just south of the east station to the south station. The first flow was the longest, and narrow at its lower extremity but wide near the pit. It was a heavy pahoehoe with aa developed in the cracks and under layers. At the south station, 12:30 to 3:30 p. m., the old channel on the rim was filled with trickle lava welling up the wall crack there, where a fountaining and spurting pot built in three hours a driblet cone 5 feet high and 3 feet across, with gas flames flaring rhythmically from many orifices in its summit. The driblet flows from this source poured into the southwest valley.

The rising was general, a driblet fountain in the west niche contributing to the floor of the west valey, and fountains played in the northwest chasm. Remnants of the northwest shelf still protruded through the flat crust of the western fill. Small overflows had poured from the lake through the rocks to the west of the northwest crag. The northeast fill was still higher, with a large driblet dome on its eastern surface, and fresh overflows from the lake had poured through the northern gap into the north wall valley. The western and northeastern fills were about 10 feet below the lake level. The lake appeared to be gaining on the crags.

The southwest station on the edge of the pit was raised into a half-dome about 6 feet, so that the artificial rock platform was tilted southwestward.

There had been a sharp earthquake felt in Hilo about 1 p. m., February 23. On February 24 there was reaction; the overflows ceased and the lake sank about four feet, so that at 7 p. m. streaming was swift through the southeast channel; the grotto rampart stood high on all sides. There was some caving in and much rumbling in glowing caverns. During the night there had been fresh flows through the north gap and from the northwest chasm. Now the northeast floor showed slumping, but the west fill was less so, and in both places hissing cones showed gas pressure. At 9 a. m. the lake was 7 feet down, with much fountaining but steady trickle, flowing in considerable volume, spread to the south and southwest from the south station vent. Inspection of the north arm at 3 p. m. showed that there also the lava was fountaining and depressed seven feet. There was temporary rising about noon, 6 o'clock and near midnight, and this tendency to a six-hour period was noticed throughout the week. On this day the southern A-frame was destroyed by a flow.

On Monday, February 25, new flows from the southeast were flooding the former course in the early morning, and a renewal at 6 a. m. pushed out arms at the southeast, east and through the east gulch. Some 800 yards of the roadway was now buried. Flows from the south vent had half filled the southwest wall valley and the rim of the pit was buried from the east station to a point

west of the south station. The northeast fill was arched up over rising lava below and new flows through the east gulch stood two feet above the ground level at the east station. At 8 a. m. flowers were here in motion, and at 9 a. m. overflow was vigorous. The crags had risen strongly. The central pond was crusted over. Rocks were falling from the east ledge. The rising of the west and northeast fills proceeded by periodical cracking and foundering of heavy crusts, driblet flows pushed out from under the margins, and flows from the lake at intervals piled up on the crust of the ponds, but eventually merged with them. The southwest valley fill was equally voluminous, but consisted of lumpy flows from the south vent. The process in general which had led to this remarkable development of new lakes in all the wall valleys may be described as prolonged intumescence followed by outburst of liquid lava up the wall crack.

At 11 a. m. there was a cascading flow from the filled and crusted northwest chasm pouring westward into the west valley. This chasm extends in a curve from a cove of the southwest channel to a circular pool at the northwest cove, and is a great rift through the west cone ridge. I was able to reach the summit of the west cone ridge and the shore of the north arm, where it was found that the formerly open arm was now replaced by a heavily crusted area with a few round pools and meandering channels. At 11:30 a. m. streaming through the southwest arm was swift to the east, but an hour later the streaming reversed and poured southward. In both cases, however, it was apparent that the northwest chasm was the source, and the pool in it stood at a higher level than the lake. There was streaming southeastward from the north arm channel, and this also came from the northwest cove pool; that is, the northern end of the northwest chasm. It is remarkable that the vents revealed by the sudden recent rising are identical with those mapped a year ago. At 1 p. m. the west niche cone suddenly broke up, liquid melt spouted like an artesian well, then with sudden tumultuous break-up the two-foot slabs of the swollen surface of the western fill cracked and foundered and splashed over the edges of the ponded area—an area, it should be noticed, distinctly higher than its margins. The surface quickly cooled to a flat expanse. I had walked over this arched area a half hour before, feeling sharp quakes occasionally in the slabs underfoot, and the cone had been four feet high and ten feet across, with a hissing gas tube of smooth lava on top.

The new aspect of Halemaumau for the week was now determined and had the following characters. A great slag heap extending 300 yards southeast across the whole eastern and southern rim sloped off beyond to new flows which persisted in activity to the south. Around the pit elsewhere great wall valleys were filling up to the pit margin and at the end of the week overflowed that margin east-northeast, north and west. The great crags rose beyond all belief, so that the higher ones overtopped the far wall of the greater Kilauea crater as seen from Volcano House. This upward movement lifted with it the shores and ramparts of the lake until the latter was near 15 feet above the old rim. As the filling of the southwest inner valley consisted of hard driblet flows, this material made a wedge between the wall of the pit and the resistless uplift of the central crags, with the result that the entire old rim from the south station westward was heaved up. This is an abbreviated description of the week's construction, and accompanying the unusual gas pressure and rapid rise of the lava were several small earth jarrings and two pronounced earthquakes. (The second one about 9 a. m., February 26.)

On February 26 general rising continued. The crust of the northeast fill was arched and broken. The west fill was much higher, about 10 feet below the shelf of the west niche, with an open pot and cone grotto in its crust. An open pond had formed in the wall crack adjacent to the west cone ,and the latter was a remarkable object 20 feet high shaped like a griffon. The southwest valley filling was only a few feet below the rim of the pit, and contained an arched oval suggesting ponding. The southwest station was now lifted 12 feet and the rim thereabouts three to five feet. The flows from the south cone vent sent out elephantine toes at the end of flows spreading like the tentacles of

an octopus. At 3:15 p. m. the lake was crusted, quiet and showed a curtained grotto on the west side of the southeast cove.

Wednesday, February 27, was a rather inactive day, with lake rising and falling, continued filling of the marginal ponds, and great lift of the crags. At 7 p. m. the northeast fill was about five feet below the level of the east station, with a long arched swelling on its northeastern side, a flaring cone at its east end and a puddle of driblet flows in motion west. There was an active fountain in the north cove pond. The slag heap pond of the west niche was five feet below the margin, and glowing toes made out from its edge along the wall valley. The cone on its summit was hissing but quiet. The view of Halemaumau from the road southeast showed only an upward slope surmounted by fire-lit mountainous crags, an occasional fountain fling in the midst, the south cone flaring stationary like a lighthouse, while below in the foreground a pattern of red glowing flows made the whole smoking mass look as though it were perforated with fiery apertures. Halemaumau was no longer a pit. It was rather a rugged hill.

A walk around what had been the pit on February 28 at 11 a. m. showed upswollen flows south, with the south cone on their crest. The southwest rim had been pushed up 9 feet, the wall remaining vertical on the pit side, but showing a half-arch profile on the outer side, the ridge being 15 to 20 feet wide. The movement had been on numerous fissures concentric to the pit, the rock moving like broken wax. Evidently the movement was very gradual. As one walked around the pit the former edge for several hundred feet was a steep obstruction which cut off the view. The nature of the structure known as the "'half-dome" which had stood on the northeast edge of Halemaumau since 1894 is explained by this uplifted southwest rim of 1918.

The filling of the southwest valley was now 12 feet above the old rim some distance west of the south station, and this sloped downward to the west, leaving only one short stretch of the old contact between floor and wall opposite the west cone. Here the floor material was a confused uplifted tumble and the west pond was an arch of crust with some slumped fresh lava north of it. The west cone ridge was now a towering crag so much uplifted that the base of the west cone was now high above the rim of the pit.

The west niche pond had an arched surface *above* the level of the margin, and trickle flows had poured out on the shelf. There were five cones close together on its surface, some of them hissing. Trickle flows were moving to the northwest crag gulch from the margins of the west niche pool, and near the old rest house north the lava was about 5 feet below the rim of the pit. The view from the west gives most strongly the impression that the central unlifted body containing the lake is a dome, and this is confirmed when one climbs to the edge of the north cove pool and finds the lake to be hardly more than a few pools in sinuous channels.

The northwest chasm had not recently been active, the lake was not now visible from any part of the rim of the pit, as it was now wholly above the rim and hidden by its own ramparts. The northeast fill was now slightly overflowing the rim of the pit east-northeast and north-northeast. Its crust was flat and a striking evidence of the very recent strong unlifting of the long escarpment of the northeast crag mass was furnished by the way this pond lapped against that mass. It lapped against a bench consisting of the upraised surface of the pond of two days before, when the pond had been at a lower level. Thus the rising crag had carried up the former pond crust with it to make a shore for the newer pond. There were no cones on the fill at this time.

The lake at 10:30 a. m. was three feet below its bank, sluggish, covered with heavy crusts, fountaining in the southeast, southwest and north cove localities. The motionless crust flats covering the greater part of the area of the north arm three to four feet above the tortuous channels which connect small ponds northeast, northwest and north with the main lake, suggest that the bottom lava has come up leaving the conduits and sink-holes open. There are at least a dozen of these known to the writer. It seems probable that the lake magma, expended in flows and fillings, is impoverishing the lake proper, while its bot-

tom material, continuous with the material of the upswelling crag dome, is coming into view.

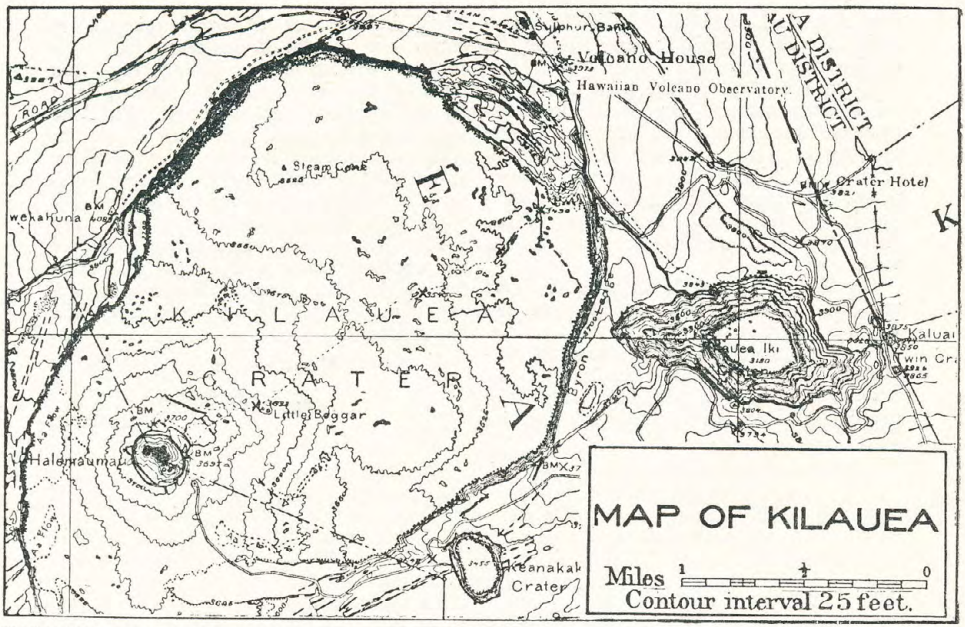
From 1 to 4 p. m. the lake was brimming southeast and very quiet, with occasional subsidences, one of these in the evening as much as seven feet with increased activity. High pressure everywhere continued. The south cone puffed loudly and occasionally spurted, and flows from this vent were again close to the road.

On Friday, March 1, at noon the lake was high and overflowing, the northeast fill was overflowing the old rim of the pit, and the general high pressure continued. At 7 p. m. the surface of the northeast pond was six feet above the ground level at the east station and its edge, in terraces of overlapping slag, threw out driblet flows eastward. Its surface was cracking, foundering and making fountaining pools locally, and flames burst through the crust. The lake was brimming full, and even above its rampart, hemmed in only by piled slabs and folded crusts. There were few fountains. Dribbling overflows took place.

On this day collections of gas were made with vacuum tubes at the front of the northeast flows and at gas jets flaming at the lake margin. Reports of surveys and of the Whitney Laboratory will be deferred.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, MARCH, 1918. No. 3

Volcano Observatory, Mar. 9, 1918.

During the week ending Friday, March 8, 1918, the Halemaumau lava column ceased overflowing and the liquid lava subsided 40 feet, with accompanying subsidence of the crag masses. The subsidence started suddenly in the early morning of March 3 and for the lake continued to Tuesday, March 5, when recovery set in. The crags continued to subside to March 6, and thereafter they became stationary. The recovery of the lake from March 6 to 8 amounted to a rise of 20 feet, or half of the previous subsidence. The renewal of gas pressure up to the present time has been confined to the main lake and the northeast fill, the western and southern border vents not yet taking part in it. On March 8 the depression of the lake below the southeast overflow margin of March 2 was 22 feet.

On Saturday, March 2, at noon, the pressure at Halemaumau was high and the lake about three feet below the southeast rim, with moderate marginal activity. The crags were rising to their maximum and rock slides were tumbling down the back slope of the northeast escarpment. A new point protruded from that escarpment into the lake at the east cove. The filling of the northeast valleys was domed up and flaming gases hissed through the cracks between its heavy crust blocks. There was a pool of collapse near its middle. At the west niche pond the cone locality exhibited an open pool of sluggish fountaining lava, and fresh marginal flows had pushed out to cover portions of the west niche shelf. At 5:15 p. m. the lake rose and slightly overflowed at the east gulch, sending a trickle of lava which poured some distance toward the stone shelter at the east station. At 6 p. m. the south cone source developed a strong flow which spread toward the southwest far into the night. On this evening the activity as seen from the Observatory in the distance was at its maximum, the splashing fountains being in full view at the southeast rampart, the north gap and the west niche, the crags towering high above the level of the far wall of Kilauea, and the glowing flows to the south could be seen in motion. Therefore the subsidence which set in after midnight was very marked, for at 9 a. m. on March 3 no activity was visible, the lake had sunk within its inner pit, and the crags were stationary. The effect of the sinking on the crags did not appear until the next day.

At 4 p. m. on March 3 the contrast to the previous day was remarkable, the lava appearing almost everywhere except in the lake itself as dead crusts, with hundreds of visitors swarming over places inaccessible before. The lake was 12 feet below the southeast rim, 15 feet down at the north cove pond, there was much fountaining and rumbling of the type characteristic of subsidence, and in the southeast arm the streaming was largely reversed, pouring northward and westward from the southeast channel to meet other currents along lines of turbulent fountaining which was expended in the eastern and central coves. There were the usual quiet spells accompanying risings and crustings occasioned by accumulating gas. The southeast cove showed a new indentation leading to the central pond. The lake showed an inner spatter bench three feet high around the southeast arm and making a point projecting from the east island crag into the central region.

The ponded lava fillings southwest, west and northeast all showed slumping and broken crusts. The northeast fill had an oval area near the northeast wall

WEEKLY BULLETIN
of the
Hawaiian Volcano Observatory

Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

which had broken in and subsided 10 feet. The west niche fountaining locality was now a cavern lined with stalactites at the side of a small pit about 10 feet deep, where under the overhang a sluggish fountain gurgled. The spatter cone at the north gap had broken and toppled over southward.

The south cone continued to puff and driblet flows from it continued to move at two localities near the road terminus. The heaps of lava of this driblet type near the cone had been swollen into humps with radial cracks in most remarkable fashion during the previous three days. That accumulation of expanding pasty lava within tunnels of its own crust was responsible for these swellings, was clearly shown by the heaving of the roof slabs and the welling of the paste up the cracks. The last lava in motion at the lower end of these flows glowed orange, showed few inflation bubbles, cooled less rapidly than the bubbly kinds and solidified iron gray, rough and very heavy, with aa fragments in the cracks.

On Monday, March 4, at 3 p. m., both lake and crags were subsiding rapidly, the movement of the crags being everywhere a reversal of the recent tumescence in the center of the pit. There was now a sagging toward that center. The lake at 3 p. m. was 18 feet below the southeast bench, but by 5 p. m. it was 25 feet down. Streaming was various and often westward through the southeast arm, there were many fountains, and stalactite rims were general. The summits of the southeast crag were now level with the southeast rim of overflow. The east island tower had collapsed. The north cove pond lay 15 feet below the overflow margin of the north gap, and the lava there was covered with dark thin festooned skins streaming westward to a border grotto from a glowing arch of crust two feet high which bridged the channel leading to the northeast cove. This channel meandered along the east shores of the north arm with three open ponds and three crust bridges before it emerged at the central region, and another crusted tunnel led from it to the larger pond of the northwest cove, which was 100 feet in diameter. The remainder of the north arm area consisted of solidified flats 10 feet above the ponds. There was a large fountaining grotto on the west side of the central region.

The west crag mass had sagged inward, opening wider the northwest chasm. The east island crag had sagged inward, tilting its spatter levels toward the center of the pit. The great northeast escarpment had sagged inward, opening crevasses and reviving the east gulch. The southeast shelf had sagged inward, opening glowing cracks along the line of the old wall. The southwest margin was little changed, but sagging of the west cone ridge had lowered the base of the west cone below the rim of the pit, and rocks were falling in a chasm east of that cone. The south cone was flaming and lava could be heard pounding inside, but the south flows were stationary. The west niche cavern had its pasty lava pool puffing at a lower level, and there was no activity at the northeast fill.

During the night the south cone maintained its beacon light, and the glow from the active lake was very bright. The crags continued to sink.

On March 5 at noon the lava lake appeared to have reached a stationary condition. Its level was from 35 to 40 feet below the eastern overflow rim, and the spatter heapings of that upper rim had collapsed into the pit. Streaming was mostly southeastward, with occasional reversals to the central and east coves, there was a large grotto tunnel with continuous fountaining and rapid inrush at the corner, which appeared to lead toward the south cone, and the overflow rim west of this tunnel line had subsided greatly in contrast to the eastern rim,

which kept its height. There was another tunnel leading to the central pond. The southeast cove was crusted, the southeast arm patterned with bright lines, and an inner bench three feet high margined the lake at the central point and the east cove. The flaming at the south cone continued. The southeast crag stood 10 feet lower than the southeast rim. The central crags had changed their shape and much had fallen away from the middle of the northeast escarpment. Falls of rock from the east ledge cliff had made a large tumble of boulders at the east gulch, and one of these had rolled out over the new lava 40 feet from the base of the cliff. The pond of the northeast fill showed fume rising from its eastern crust and a glowing cavern under the overhang of its northern margin. The crust over the west niche pond remained high. During the night the pit was less luminous.

On Wednesday, March 6, at noon, the depression was about the same, but the lake was rising. A new spatter margin had formed with crescent domes southeast, east, at the central cove, at the west, in the north arm and in the southwest arm. Streaming was swift southward from the southeast narrows, the southeast arm was crusted over, and the four grottoes of the southeast cove were spraying. The crags and floors were lower.

A new cone was developing in the northeast valley pool, and a small lava flow trickled from it over the collapsed blocks. At its source a block heaved and occasionally released a puff of gas. The pools of the north arm were slightly higher, there were five or six active fountains at the tunnels, and the crusted region stood lower. The northwest chasm contained an active lava pool 12 feet down and fully 20 feet above the lake level. The west niche cavern was nearly dead, with dull glow in the cracks. The southwest pond was bordered by a floor at its east end, which had subsided 15 feet below the level of the south margin of its pit. The liquid was 20 feet below that margin, with eastward streaming, and with fountains south and southwest. Activity at the south cone had ceased. Glow from the pit at night was moderate, and much greater southeast than northwest.

On March 7 the old edge of the crater was again defined except at the west niche and southeast rim, the crags were stationary, and the fume was somewhat denser. The fume had been thin March 4 and 5. During this day the lake rose from a depression of 30 feet at 10 a. m. to less than 25 feet at 5 p. m. Fountains were few both southeast and in the north arm. A fountain was boiling in the northwest chasm. The southwest pond was chiefly active at the south tunnel corner. In the morning the cone of the northeast pond was quiet but glowing, but at 4 p. m. it was puffing and ejecting lava spray. The west niche cavern was inactive. At 6 p. m. the lake was only three feet below the partition crust separating the southeast cove from the central pond.

On Friday, March 8, at noon, the lake was 22 feet below the southeast rim and rising, its surface level with the entrance to the central pond. It was actively building new spatter margins everywhere, the tunnels were submerged, and its inner bench was being overflowed at the central and eastern coves and across the flats of the north arm. In this northwest region it was evident that the north chasm pond was higher than the northwest cove pool, the latter higher than the north cove, and the north cove higher than the central region. There was thus a distinct grade downward from the wells of uprising west to the sinkholes southeast. There were many border grottoes and a hissing cone in the middle of the north arm showed that gas pressure had been renewed. The lake was submerging the shores of the southeast crag and the east island crag.

There was as yet no renewal of rising in the crags, and hissing was not heard from the vents of the outlying ponds northeast and west, nor from the south cone. A large cone, however, had been built above the sunken slabs northeast.

A notable change, probably indicative of gas rising through the rocks, is the recent whitening by solfataric deposits of the region just north of the north station, in the vicinity of the three old driblet cones of 1894. The collection of gas samples was continued during this week.

Volcano Observatory, Mar. 16, 1918.

During the week ending March 15, 1918, the lava crags in Halemaumau have slowly risen and the liquid lake also rose, but tended to subside relative to its containing basin on Thursday and Friday, March 14 and 15. In general, the week may be said to have continued the recovery from the recent subsidence so far as the main lava column is concerned, but the liquid lake at the end of the week was 10 feet lower than at the beginning. All of this and more was recovered on March 16.

On March 9 at 10 a. m. the crags were stationary, but three hours later they were rising. The night had shown dim glow as though from a rising lake. The movements of the east ledge crag had produced a deep notch at the east gulch. At 1 p. m. the fountain of the north cove pond could be plainly seen from the Observatory. From 10 a. m. to noon there was strong rising so that the bench west of the southeast cove was flooded. Just after noon the lake subsided two feet and then recovered. At 10:30 a. m. flows were in motion from the cone in the eastern part of the northeast valley pond. At noon the north cove pond was quiet, but the northwest cove pond was brimming level with the surrounding floor and fountaining near the center with high flings. Fumes were dense in the vicinity. After 2 p. m. there were more overflows of the west shore of the southeast cove, and there were many fountains about its margins.

On March 10 at 1 p. m. the crags had risen farther. At 2:30 p. m. the lava of the southeast cove was little changed, the southeast bench standing 20 feet above it, while the bench on the south side of the cove sloped downward to the west so that in places the lake was only four feet below it. Streaming to the southwest margin was fairly rapid. At 3:30 p. m. the northwest cove pond was brimming and active, and the north cove pond quiet. At 4 p. m. the lava was high and fountaining in the northwest chasm. At 6 p. m. the lake at the southeast cove had risen flush with the floor at the gateway leading to the central pond. There was a curtained grotto farther north on the west side of the cove and a line of fountaining grottoes on the southeast side.

On Monday, March 11, the lake was a few feet lower relative to its basin, the grottoes were more active, and the streaming was swifter. There were a few fountains in the southeast arm. At 8 p. m. a small cone in the central part of the north arm was puffing loudly and occasionally ejecting spurts of molten lava. The northwest cove pond was fountaining and three feet below its marginal rim.

On March 12 at 5 p. m. inspection of the lake was difficult owing to clouds of steam from the fresh flows occasioned by heavy rain which continued for three days. Steam made an impenetrable fog so that travel in places was impossible. The lake's edge, however, was reached at the southeast bench, and the liquid showed all the signs of active rising. Fresh overflows had poured toward the hollow of the central pond, which appeared to be lower than the lake. There were fountaining grottoes southeast, a filagree curtain veiled the hissing grotto under the southeast crag, and the lake once more appeared to be gaining on the crags. There was a hissing cone in the central pond floor. The east ledge crag appeared low relative to the southeast bench as though the latter were rising. The northeast fill appeared comparatively low as though slumped, great clouds of steam rose from it, and no noise could be heard there.

On March 13 conditions were about the same. On March 14, however, there was subsidence of the lake relative to the southeast bench, which stood 30 feet above it. A circuit of the pit from 10 a. m. to 12 noon during a driving southerly rain produced the following notes. The fresh flows were followed along their southern margin to a point near the south cone, which was quiet, and no noise could be heard from the inner pits southeast or southwest. The southwest margin of the outer pit remained a high ridge as before, but near the southwest station the inner filling had been lifted higher and the base of the west cone was again above the rim of the pit. Glimpses of the crags through the rain vapor revealed them towering high. No noises of activity were heard at the western stations, but at the north a thudding rumble could be heard from the direction of the north arm. Fume mixed with the steam made the northeast rim of the pit impassable and suggested activity in the

northeast fill. By making a detour the east station was reached, and during a heavy downpour strong rumbling with explosive noises and jets of blue fume started in the northeast valley. Some kind of spurting activity was going on there, which later exploration showed to be from the cone east of the north station, which ejected high spatter and a flood of very liquid lava in an unusually explosive fashion. Inspection of the hot cracks and "Pele's Kitchen" showed no changes in that region. At 4 p. m. the southeast cove was reached and the lake seen to be 12 feet below the south bench and 30 feet below the southeast bench. There was high activity and rapid streaming in the direction of the central pond, with traveling fountains and all signs of subsidence. On March 15 the low level of the lake continued, but the crags were rising.

During the past month of storms, lava overflows and exceptionally heavy rains, the seismometric records of the Whitney Laboratory have been as follows:

During the week ending at 2 p. m., February 22, 1918, no definite earthquakes were recorded either local or distant. It is doubtful whether the disastrous shocks of Amoy, China, could have been registered here owing to the excessive vibration due to high winds. The tilting of the ground became very excessive to the south, and changed from slight west to moderate east. Microseisms and volcanic (?) vibrations were excessive owing to the storm, moderating at the end of the period.

During the week ending at 2 p. m., March 1, 1918, six local earthquakes were registered, of which one was felt strongly in Hilo and another strongly felt at Volcano House. On February 23, the day of first lava overflow at Halemaumau, a small shock was registered about 4:30 a. m. and at 1:06 p. m. came the Hilo shock, of much greater amplitude on the seismogram. A small shock at 7:35 a. m. February 26 was followed at 9:42 a. m. by a smart quake which rocked the buildings and threw all the recording pens off the cylinders. On February 27 there were two small shocks at 4:27 a. m. and 6:57 a. m. and numerous vibration spasms. Tilting became so excessive to the south that the instruments were readjusted February 26—probably a fixed alteration of the vertical was indicated. Tilting increased to the east strongly, and with it there was moderate recovery to the north from February 26 to March 1. Microseismic and volcanic vibration were moderate at first; the latter became spasmodic on the 27th, and thereafter excessive wind squalls obliterated the seismic effects.

During the week ending at 2 p. m., March 8, 1918, six local earthquakes were registered and numerous spasms of volcanic vibration. Five small shocks occurred during the twenty-four hours when the Halemaumau lava changed from rising to sinking, March 3 to 4; these were at 4:07 and 5:15 p. m., March 3, and on March 4 at 2:59 and 11:20 a. m. and and at 12:08 p. m. Another shock was at 4:04 a. m., March 8. Tilting to the east and north ceased and tended rather to the west and south. North-south microseisms were strong throughout the week.

During the week ending at 2 p. m., March 15, 1918, three local earthquakes were registered. The first two of these were very small, at 6:28 p. m., March 8, and at 7:23 a. m., March 10. A stronger felt shock occurred on March 10 at 8:06 a. m. Movement of tilting increased to very strong west and south. Microseismic motion, dominantly north-south, decreased at the beginning of the period, but became strong and rhythmic later. Volcanic vibration increased to a maximum on March 14, coincident with the activity of the explosive cone in the northeast fill of Halemaumau.

Volcano Observatory, Mar. 23, 1918.

During the week ending Friday, March 22, 1918, the lava lake of Halemaumau has risen 12 feet and the crags have also risen until the high central peak is again in line with the far rim of Kilauea crater as seen from the Observatory. The fountains both east and west are again in view from Volcano House, and the level of the southeastern rampart of the lake is only about 5 feet below the level of overflow of February. The latest movement of rising has been slow, and the only outlying area to take part in it is the northeast fill, which has continued to put out sluggish flows upon the floor of its depression. The February flow area is still very hot, especially in the

region of swollen domes near the south cone. The most remarkable crag uplift of the week has been the rise of the southern portion of the west cone ridge, which has created a new sharp escarpment between the west cone and the southwest channel, the whole block standing high above the old rim of the pit.

On Saturday, March 16, 1918, at noon, the lake was rising and mostly crusted over at a level in the southeast cove 18 feet below the southeast shelf and 6 feet below the south bench. Stalactites were abundant on the spatter margin above the lake, there was high gas pressure with ballooning crusts, and surfaces occasionally cracking and foundering while driblet lava pushed out from under the crust along the shores. The crags were slowly rising. An oval pot in the central pond area was pouring out driblet flows which covered the whole crust of the pond in the course of an hour. At first the pot was ballooning a flexible skin sluggishly and emitting a flame through cracks in the skin, but at 1 p. m. a noisy spurting fountain developed there, and then the lava subsided about 3 feet, leaving an oval ridge around the margin. Fumes of sulphur were rising from the south cone.

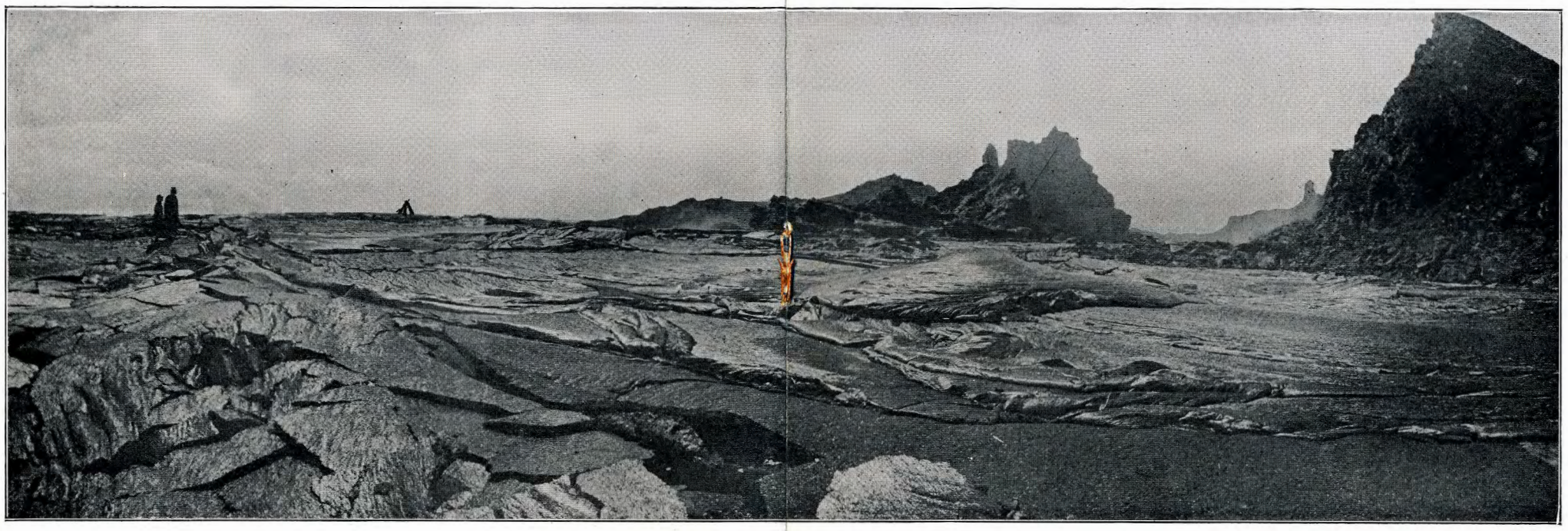
Exploration of the northeast depression revealed a remarkable change at the western cone locality. The cone was now a fuming pot 5 feet in diameter, surrounded by a splash veneer covering all the adjacent surface 50 feet or more from the center with thinly festooned and blistered glassy lava radiating in flows which must have been very liquid. This contrasted strongly with the earlier lava in its glistening gray surface and brittle smooth crusts. The ejection had been explosive, for there were solidified splashes, droplets and shreds of the melt thrown to a distance and the surface of the flow lava was pitted with the spray driblets which had fallen already solidified. This lava was in such marked contrast to all the rest that it may well have been produced on the morning of March 14 by torrents of rain water in the cracks reaching the liquid pool below. It will be remembered that an explosive rumbling was heard there through the fog at that time.

Nothing new was observed north and west except that the west cone ridge seemed higher. The southeast crag was now low and without peaks.

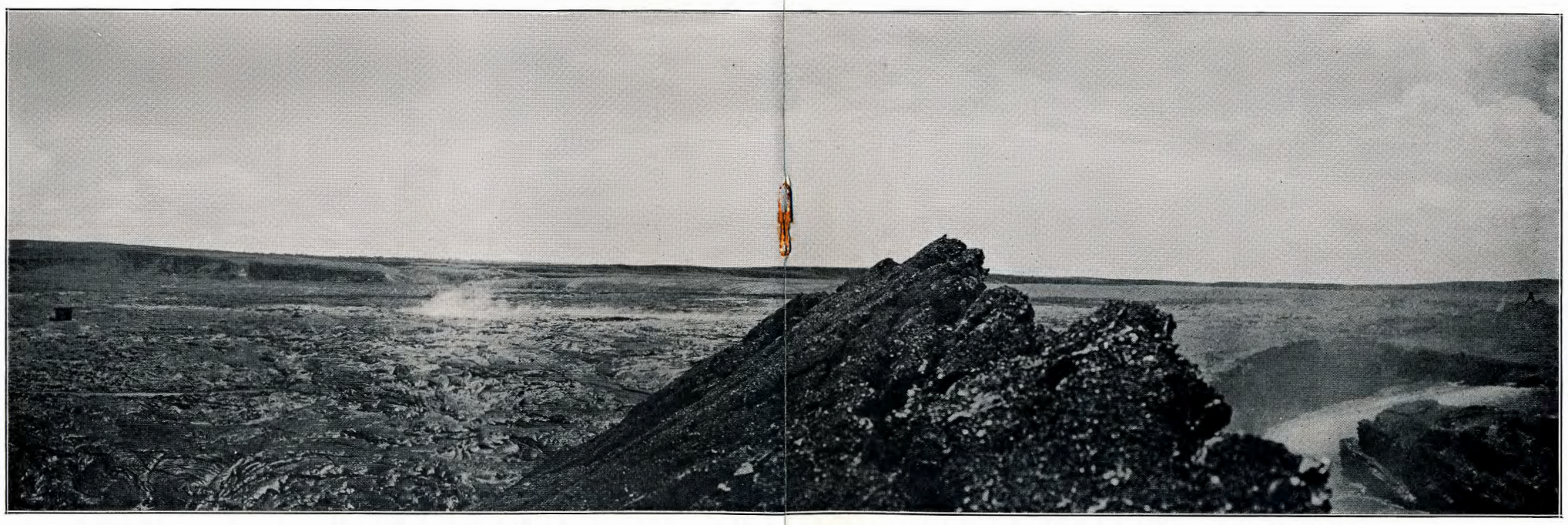
On March 17 at 3:30 p. m. the depression of the lake was about the same and there was lava flowing in the central pond. On visiting the north gap at 4 p. m. a new cone was found with an open pot where lava boiled and a flaming crack was active beside it. The northwest cove pond was brimming level with the edge around it and fountaining, and the pond in the northwest chasm was crusted over. At 8:30 p. m. there was some subsidence and renewed activity in the southeast cove, the southeast arm remaining crusted.

On March 19 at 9:50 a. m. the lake had risen so as to build a new rampart two feet above the level of the south floor and the lake stood three feet below this rampart. The southeast cove was crusted over and the streaming was reversed from its original course, pouring outward from the cove to the southeast arm where the current met the streaming from the west in a line of foundering and fountains, extending between the southeast crag and the east cove. A new floor platform had been built at the east cove, and a new crescent dome at the east gulch to which there was local streaming. The only dome grotto in the southeast cove was on its northwest side. All around the lake a new spatter margin had been built about three feet high. The southeast crag was greatly lifted from its former position below the level of the southeast bench, for its summit now stood fully 15 feet above that bench. The southeast bench stood 12 feet above the lake. Over the southeast tunnel grotto there was a small blowing cone on the bank, surrounded by sulphur stain. The central pond was crusted over and its cone hissing but showing no special incandescence.

The activity in the southeast cove was as follows: 9:30 a. m., temporary crusting of southeast channel, skin stagnant in southeast arm, streaming to southeast crag grotto on northwest side of southeast cove. 9:45 a. m., northward streaming resumed and southeast cove stagnant. 10 a. m., two-foot subsidence, vigorous southeast streaming restored, incaving margins and many fountains. 12:30 p. m., lake a little higher, streaming northward resumed, and heavy foun-



Feb. 23, 1918. Halemaumau overflowing, from near east station. A-frame left, central crags, East Ledge Crag on right.—*Photo. Jaggar.*



March 8, 1918. The new overflows looking southeast, old trail on the left, from summit of East Ledge Crag. "A" on the right is where the A-frame formerly stood, at the new south cone.
—*Photo. Jaggar.*

taining at the point of conflicting currents in the southeast arm.

The south cone stood 8 feet high, with crevasses on both sides of it and a secondary cone 15 feet to the northeast of it, both of these standing on the crest of a cracked and upswollen ridge which extended for 200 feet along what had been the southern wall crack of the pit.

Exploration of the southwest pond at 9:50 a. m. revealed the fact that its southern wall margin had been lifted 20 feet and was becoming a craggy escarpment with a greatly-steepened southern slope and white smoke rising from its summit. The pond, like the rest of the lake, showed a three-foot spatter margin, an active grotto at the south tunnel, and looking across to the north it was seen that a broad new platform had been built on the northwest side of the western deck extension of the central crag mass so as to narrow the southwest channel to a long curving chasm between this platform and the west cone ridge.

The eastern depression of the northeast fill showed active driblet flows in motion and heavy glowing accumulations of lava which had welled up through cracks in the floor.

The north cove pond was now almost obliterated, built over by a heavy floor containing a spurting pot which occasionally burst into violent fountaining, and a spatter cone three feet high which sometimes hissed harshly. A little to the north where the old pond rim had been, the second active orifice was an oval glowing pot two feet across, lined with spatter stalactites, and next to it a flaming crack, over live lava which could be heard roaring below, exhibited crowded stalactites at the orifice of a glowing chamber which were unquestionably the products of remelting of the walls and suggested the cavern type. These stalactites were bearded with delicate fibrous needles.

The remainder of the north arm area showed central and northwestern ponds; the northeast cove appeared extended eastward and four or five conspicuous pinnacles margined the east island mass on its west side. An active grotto hung with an arch of stalactites was bubbling on the north side of the northwest cove pond with surface streaming towards it. The general floor of the north arm stood five feet above these ponds. Very heavy white smoke rose from cracks in the older rim of the north arm at the base of the northwest crag.

The crags had been rising slowly, especially in the center, the most marked change being the uplift of the southwest floor.

On March 20 at 4 p. m. the lake was still high and had built a very large half-dome at the south margin of the southeast cove. The pool was crusted, rising, and under high gas pressure, with spraying outbreaks at the margins, especially at the east gulch and at the south grotto. The grotto under the southeast crag was quiet and showed a high arch lined with stalactites above it. Everything indicated renewed strong gas pressure just at the equinox. At night the brilliancy of the pit as seen at a distance was increased and the actual fountains of the southeast cove could be seen from Volcano House. The crags were definitely higher, conspicuously rising above the far edge of Kilauea as seen from the Keanakakoi flats, and the uplift of the preceding twenty-four hours was specially conspicuous in the south pressure ridge and its western extension making a lifted escarpment all the way to the west cone ridge. The latter was broken through by the northwest chasm, and the southwestern half was rising higher than the northern portion, making a distinct peak above the bend of the southwest channel. This peak was much higher than the west cone itself, a prominent feature some 15 feet high and its base again above the level of the western rim of the pit. A new jutting peak of rock protruded from the summit of the south pressure ridge. The swollen new lava hills near the south cone are still hot and stand high and are much stained with gypsum, and there is similar staining elsewhere in the new flows, especially over the old wall crack and the old flaming zones. The swelling of the south cone hillocks appears to have continued after the flows ceased. A very conspicuous ridge has swollen up over the main tunnel extending southward from the south cone. Its top is the summit of the heaping and shows lengthwise cracks distended by a bulging fill of lava which rose from below and

small gas spiracles are distributed along the surface of this lava.

On March 21 the high activity continued. There were occasional large central fountains, hissing and flaming glow cracks and gas spiracles were built in the bank at the southeast corner of the southeast cove. There was much ballooning of skins and southeastward streaming. The lake margin had become easily accessible at the east gulch where there was no activity. No flows were in motion at the northeast fill. The northwest cove pond was fountaining, the north cove cone was hissing strongly, and there was moderate flaming at the pot farther north. There was also an active cone in the middle region of the north arm. No activity could be seen in the northwest chasm or around the western rim. In the evening the lake flooded the bank at the east gulch and the fountains were plainly visible at Volcano House, not only southeast, but also north and northwest. Late in the evening there was temporary subsidence and a fall of the spatter bank under the southeast crag caused a strong wave.

On March 22 in the morning the lake was about 4 feet lower, fume was thin and the fountains were no longer visible from the Observatory. In the afternoon the fumes became very dense. The crags retained their height.

In the Whitney Laboratory the seismographs, for the week ending at 2 p. m., March 22, 1918, have registered faint traces of possible teleseisms or distant earthquakes March 16 and 18, on the latter date about 2 p. m., and one local earthquake about 10:54 a. m., March 22. The excessive tilt to the south and west was compensated by gradual recovery to the north and east. March 19-22. Microseismic motion diminished from strong to moderate during the week. Volcanic vibration increased and became strong on March 20, diminishing thereafter.

Volcano Observatory, Mar. 30, 1918.

During the week ending Friday, March 29, 1918, the lava lake and crags of Halemaumau continued to show the effects of the equinoctial rise until March 26, when very sharp subsidence set in which has continued so as to lower the lake 50 feet below the southeast margin, and all the crags have gone down with it. A singular coincidence of this subsidence has been a marked decrease of fume density, instead of increase such as commonly showed very promptly in the past when the lava went down. Coordinate with this has been the considerable density of fuming which marked the recent rising spells, also contrary to the rule. Assuming thin fumes due to more complete combustion of the gases, the explanation of the anomaly appears to be that increase of crusted and craggy areas over the very large surface of the upper rim of Halemaumau produced more condensation tunnels and less complete combustion, whereas the present subsidence has demolished those tunnels, opened larger liquid areas and increased both the fountaining activity and the combustion. The rapidity of the present subsidence is the greatest this year and is accompanied by southwestward tilt and numerous perceptible local earthquakes. This is in accordance with precedent for the period immediately following equinox. The nature of the subsidence appears to be a withdrawal of liquid lava through sinkholes at the east and south, and withdrawal of the bench magma vertically downward near the center of the pit. The effect of this is to flatten the hitherto steep surfaces which sloped away from the center and at the same time to produce sagging depressions and crevasses in the three great wall valleys. The crags, still in full view from the Observatory, are subsiding fast, and the fountains are no longer visible.

On Saturday, March 23, at 10 a. m., the lake was about 5 feet below the bench at the east gulch, rising about three feet towards noon. Spatter margins had been built higher and a large dome in the southeast corner showed long stalactites with glowing interstices. After a spell of breaking up the lake crusted over. The grotto on the southeast crag side had collapsed and there was a line of solfataric fume and stain extending from the lake along the boulder-filled depression of the east gulch. Heavy fountaining noises could be heard from the southwest cove. At night the fountains were very brilliant in the southeast and north arms.

On March 24 at 3:45 p. m. the southeast bench stood about 8 feet above the

lake, which rose two feet in the course of two hours. The two cones of the north cove were puffing noisily, the northwest cove pond was 3 feet below its rim and crusted, and the fumes near its north bank were dense. At 6 p. m. the risen lake southeast was very quiet, with only one grotto in action. In the evening two fountains southeast and one northwest could be seen from the Observatory, but during the night the intensest illumination was in the center and the southwest cove, bringing the middle crags into silhouette.

On March 25 at 5 p. m. the southeast margin of the lake was two feet below the newest spatter rim, large domes had formed along the southern rampart, and the southeast shelf stood about 6 feet above the lake surface. At 5:30 p. m. there was subsidence of about a foot, with general break-up of crusts, very rapid streaming and enormous fountains migrating across the southeast cove with much bubbling. An open glowing cupola could be seen behind the stalactite curtain within the corner dome southeast. The central pond depression was smoking; the crags were little changed.

The east island crag had recently developed a conspicuous spire rising above its serrate top. In the northeast depression new flows were heaped up and driblet flows were in motion on the east side of the blister lava area. These came from a rough cone bearing bearded spiracles and flaming, hissing gas cracks.

At the north gap cone the pot was inactive, but a glowing crack hissed on its margin and deposited yellow sublimates. The north cove cone had small spiracle heaps on its summit and yellow stain and one of the holes was hissing and flaming. Rocks fell from the west end of the north smoke crag, which was cracking on the north station side; this crag, at the west end, seemed higher in profile than the eastern end of the northeast crag mass. The lava in the northwest cove pond was high and crusted with a sluggish fountain ballooning the crust and belching gas at the north corner. The site of the north central pond was occupied by two cones.

The west niche was dead, and in the northwest chasm the floor of crust was 12 feet down, and a bright yellow solfataric area had formed on the west margin of the rim. A hollow blowing sound could be heard below, but no glow was visible. Gas collections were made on this day southeast, northeast and north. The glow from the crater on this evening was dim.

On March 26 the crags were slightly higher, the fume was rather dense, no fountains were visible in the daytime from the Observatory, but in the evening moderate fountain action was visible.

From 4 to 5 p. m. the lake was high and little changed. The central region and southeast arm were very heavily crusted, fountains were playing in the southwest arm, on the west side of the central region, in the northwest cove pond and at the southeast cove where, as usual, the streaming was southward. At the southeast stalactite grotto there was steady inrush. At 5:30 p. m. the southeast cove fountains were throwing spray high above the south margin.

Flowing had ceased in the northeast depression. At the north gap the cones still hissed, but the rim pot was nearly dead, making much odor of free sulphur through a small glowing marginal crack, and the sulphur-colored areas were larger. The north central cones were still in place. The west end of the northeast crag mass was greatly crevassed and fallen away, and there had been much rock tumbling also at the east gulch. It was evident that motion in the crags was becoming irregular, and there was much humping and crevassing of the northeast fill, especially away from the fresh flows of the extreme northeast part. There was also bulging and sagging in the floor of the north arm area. The grotto pit of the west niche was full of broken rocks and dead. The southwest crag mass appeared higher and also the east side of the northwest chasm, but this last appearance may have been a sinking of the west side.

On March 27 at 10 a. m. the lake surface stood 12 feet below the southeast shelf, there were no marked changes, the crags were lower, but the top of the southeast crag was still higher than the southeast shelf. In the evening falls of rock were reported, and from a distance the pit appeared dull except for bright glows occasionally with sudden flaring. A small earthquake was felt.

From the Observatory at 9 a. m., March 28, it was clear that strong sub-

sidence had started. The crags were lower and both the north and southeast lake corners were smoky. At 4 p. m. the lava southeast was 15 feet below the southeast shelf and 11 feet below the rim of recent overflow at the east gulch. The southeast cove was continuously active, with rapid southward streaming and traveling fountains. Inspection of the north arm at 5 p. m. showed that the whole east half of the floor had collapsed, making once more an open lake which joined the north central and north cove ponds. The northwest pond was still enclosed with walls about 8 feet high. At 11 p. m., seen from a distance, the crater was very bright, especially towards the north, there was much flaring during the night, and the crags subsided so that the central peak as seen from the Observatory appeared well below the southwest wall of Kilauea crater.

On March 29 at 5 a. m. another small earthquake was felt and at 8 a. m. the crags were lower and the fume was very thin. At 3:30 p. m. the lake was found to have subsided profoundly so that the southeast shelf stood 40 to 50 feet above it. The central group of crags had also sunk and the southeast crag was fully 10 feet below the surface of the southeast shelf. Crags were opening along the line from the southeast grotto to the south cone. The latter had collapsed, puffing sulphur fume rose from an open crack west of it, there was a broken area all around, and dark red glow could be seen 10 feet down the cracks. The activity was not much changed, streaming was southward in the southeast cove, while the southeast arm and middle region were crusted over except for a large fountain at the west side of the lake. There was bombardment at the base of the southern and southeastern cliffs of the southeast cove. The high cliff beneath the southeast shelf showed some overhang. The east gulch was deep at the lake shore, but choked with stones fallen from the east ledge a short distance away. The latter had subsided and flattened its back slope. The east island crag mass showed marked inclination towards the center of the pit of its spatter level of the previous day, and a glowing cavern was revealed at the east cove lake margin.

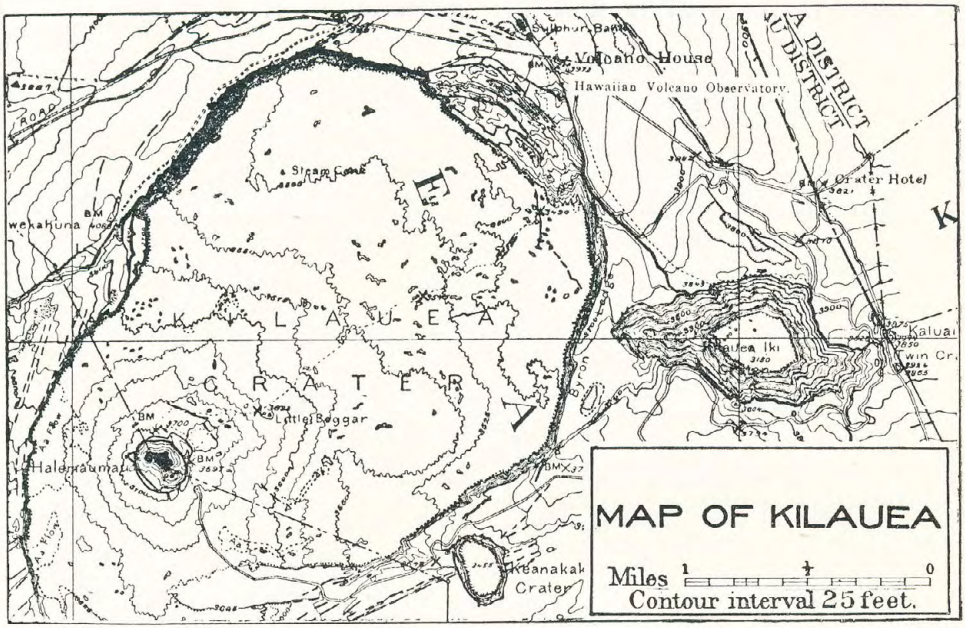
The central pond had a glowing and flaming heap on its east side. The depression northeast was lower, there were small pits of collapse and open crevasses near the northeast wall and in the middle of the northeast fill very hot air rose through big cracks from glowing depths. The north arm lakes were 30 feet down and very fumy, with sluggish activity and the cones gone. The westward slope from the northwest chasm was flatter, so that the central region was again visible from the northwest rim of Halemaumau. The southwest crag and west cone was still relatively high. At the southwest floor, however, the slope leading up to the cliff over the southwest pond was much flatter, the pond stood 30 feet below, with continuous fountaining at the south tunnel, and the southwest channel had widened. The inner bench on the east and north sides of this pond stood 10 feet above the lake, but the corresponding bench on the south side was 10 feet higher, showing that the central crag mass had subsided more than the southwest block. The pond was mostly crusted over. Huge crevasses had opened in the floor north of the south cone and everywhere around the pit. Such crevasses showed the internal incandescence of the bench magma to be only 12 to 15 feet below the surface.

In the Whitney Laboratory of Seismology nine local earthquakes have been registered during the week ending at 2 p. m., March 29, 1918, and also smaller tremors which would hardly rank as quakes. This was all accordant with the change from rising to sharply sinking lava. At least three or the shocks were felt at Volcano House. The times were 11:09 p. m., March 23; 7:23 p. m., March 25; 9:47 a. m., 8:30 a. m., 9:48 p. m. (felt), March 26; 7:38 p. m., (felt), 9:40 p. m., and many tremors March 27; 6 a. m. (felt), 9:24 a. m., March 29.

Microseisms throughout the week were moderate, volcanic vibration was at first strong continuously and later strong in shart spasms. Tilting movement, from a trend at first eastward and northward, changed on March 25 in the north-south component to strong southward, and the next day in the east-west component to westward, and thereafter the southwest tilt increased.

Very respectfully,

T. A. JAGGAR, JR., Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. All scientific exchanges should be sent to this address.

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, APRIL, 1918. No. 4

VOLCANO OBSERVATORY, April 6, 1918.—During the week ending Friday, April 6, 1918, the subsidence continued and reached its maximum movement about April 2. A comparatively stationary condition of the bench magma as represented by the central crag was indicated between April 3 and April 5 while the lava lakes during this interval rose relative to the crags. At the time of writing this rising of the lakes continues vigorously and appears to mark a distinct recovery from the subsidence. The maximum depression reached, measured roughly April 3 and April 5, was 240 feet for the lake surface below the east edge of Halemaumau near the stone shelter. The central crag stood 108 feet above the lake. Although the lake appeared to be rising and greatly flooded the floors between these dates, this action must have just compensated the subsidence for both dates gave like measurements. Hence the depression limit appears to have been reached April 4.

The sinking lava column was being withdrawn down the Halemaumau shaft from March 26 to April 4, a period of nine days, from a high level which had flooded the Kilauea inner cone for over a month, the total subsidence amounting to at least 260 feet below the overflow rim southeast. The effect of this movement was to restore the old Halemaumau pit, with its margins filled out where depressions had been and in a few places broken away where the edge had been crushed and loosened during the rise. Constructive effects have been greater than destructive so that the pit is smaller and much more symmetrical, the north-eastern and western niches being now filled with new lava. The subsidence carried down the greater crags intact, the lake maintained relation to the crags in form and action essentially unchanged. The debris slopes eventually encroached upon its outer shores. These tumbled slopes when they fell in the lake, clearly evinced the presence of a shallow lake bottom flying at flat angles by choking the channels and pools. Numerous localized small earthquakes accompanied the movement of subsidence, increasing in vehemence as it increased and ceasing completely when recovery began. During the maximum these jars were quite perceptible at the edge of the pit. The fumes have been extraordinarily thin and the presence of eighteen or more vigorous lava fountains building cones shows that combustion of the gases is very complete. A spectacular feature of the rock slides which accompanied the depression was the caving away of the still incandescent lava fillings on the northeast and west, which were sufficiently mobile to ooze outward on the broken face of the cliff as very stiff aa lava which then broke and flaked away in large blocks making by night stupendous fiery avalanches into the depths below. Halemaumau is no longer a hill, it is a pit as of old with the whole panorama of craggy hills and five bubbling fiery lakes spread out in plan beneath the visitor.

On March 30 the whole Halemaumau landscape of crags, ridges, chasms, lakes and plains very gradually subsided and so rapidly that the rocky hills which have been a feature of the view of the pit from the Observatory for over three months had disappeared by the next day, hidden by the rim of the pit. There were no avalanche clouds, small rock falls took place but no great ones and angular measurement, during the subsidence, of fixed points on the old rim, failed to detect any subsidence

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Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

there even when the inner crags were sinking rapidly. The fume was very thin.

At 5 p. m. the lake was over 100 feet below the rim, the new pit was defined, the southeast shelf remained erect, the lake was enlarged by marginal collapse, the central pond was active and the crags kept nearly the same relation to the lake as during the high levels. An immense overhanging cliff beneath the southeast shelf descended all the way to the liquid lava of the southeast cove, but this did not imply a sinking of the liquid within its basin by that amount, for the entire containing basin had sunk with the liquid, parting from the southeast shelf along great fault cliffs where the east gulch and south crevasses had been. In fact just at this point the subsequent fall of broken rock into the lake quickly filled it and closed the channel which had previously led to the southeast cove, showing that its basin was shallow.

The new Halemaumau rim extended the southeast shelf to follow approximately the line of the former 1894 bench on the northeast side of the pit, but at a much higher level. The old cliff line remained on the north, a new cliff crossed the west niche. The southwest margin which had been pushed up, now crumbled away somewhat, enlarging the old pit in that direction only; while from the south cone to the southeast shelf there was a new cliff considerably inside of the old pit edge.

The summit of the stiff cylinder which constituted the moving lava column inside the pit had on it as before the northeast valley floor, the northeast crag mass, the east island, the northwest, west and central crags with the outlying floors, pits, chasms and escarpments and the lake in the midst, all the activities of the whole scene, smoking vents, fountaining grottoes and streaming channels maintaining their usual habits quite regardless of the fact that the entire relief map of which they were parts was sinking into the depths at a rate which averaged more than 50 feet a day. It was an astonishingly complete demonstration that the lava lake and its feeding tubes constitute a mere surface mechanism in a substance capable of moving en masse.

On looking down on the new fill northeast occupying the old crescent-shaped 1894 wall valley somewhat outside of the true pit margin, it was seen that the drainage of remnant liquid out from under the cones which had been making flows five days before had left deep tunnels and pits all glowing within, the luminescence showing every detail of a cavernous space with a roof shell 10 feet thick, the interior, apparently 40 feet high, revealed through a ragged hole 50 feet across. When a block of the roof shell fell in, the broken rock was seen to be of bright yellow incandescence, while the cavernous space was rather orange red. Some 40 feet in front of the east shelter enormous gaping crevasses were seen at the base of the new wall. Farther west along the northeast valley and in the depression under the north station these cracks glowed inside and occasionally their walls collapsed.

Looking into the north arm of the lake the liquid of the large north pond was seen to be fountaining with high flings of melt and receiving a cascade flowing northward from the north central area. It had greatly enlarged and lowered. The lava stood some eighty feet below the north gap, but the northwest pond in its separate pit appeared to be at a much higher level and also fountaining. An isthmus separated the northern lakes from the central region.

At 6:30 p. m. the lake appeared as though rising, but the marginal cliffs appeared higher. The east ledge in subsiding was separated from the southeast shelf at what had been the east gulch by a crack which could be traced all the way to the bottom of the inner cliff and

this marked the contact plane between the subsiding bench magma and that portion of it which was locked to the old rim by the new overflow—namely the southeast shelf. The summit of the east ledge was now down to the level of the southeast shelf. Only the central crags appeared still a very little above that level. The southwest pond was a deep active pit. The southeast cove had broken out an embayment in the direction of the south cone. The south floor had sunk in steps with cliffs and crevasses between it and the southeast shelf, making it now quite inaccessible, where on the day before the writer had walked across it to the central pond. Both the southeast and southwest arms had widened, there was a deep cove in the north face of the central crag mass and the whole north region of the lake looked wider. There was a glowing pit and a floor cone on the northwest side of the central cove. So much had the lake subsided that the north arm was now visible from the southeast shelf. Fountaining was moderate in the southeast cove and there was the usual broad zone of streaming to the southeast. During the night brilliant flaring could be seen above the pit.

On the morning of March 31 all but the extreme tip of the central crag had disappeared from the distant view. At 10 a. m. it was seen that the inner circle of crags had moved down more than the outer circle, the latter tending rather to hinge against the outer walls and flatten their centrifugal slopes. Between these two portions of the lava column were depressions such as the northwest chasm, the southwest and central ponds and the cove valleys. Evidently the inner lava column moved down fastest and there is probably some concentric fissuring which separated the central core from the outer ring.

The depression continued all day with small rock slides, especially west, north and east, some red dust, much opening of crevasses and thin fume. So gentle was the subsidence that the delicate sculpturing of the west cone, the east island spire and the hanging central crag pinnacle kept their positions uninjured even while being carried down bodily. Bench remnants still clung to the upper walls north, west, south and southeast. The south cone and the southeast shelf remained on the upper rim. Moderate incandescence was seen in the cracks. There was a splashing fountain in a pot in the central pond, the several lakes were surrounded by inner walls about 15 feet high, there was a live pond in the northwest chasm and ten or twelve border fountains were in action in the lakes which occasionally showed spells of breaking up and foundering crusts. Streaming was mostly to the southeast. Now and then a fall of rock into the lava would start action.

At noon Monday, April 1, the same general relations held, everything was lower, avalanches wer stronger and the highest crags were far below the rim. The southeast shelf had fallen away and was much narrower and the rock falls from it had plastered the southeast crag with sheets of lava splash. The lake had somewhat diminished in size, a fresh spatter rim five feet high was built around the main lake and streaming was westward in the northwest pond, southward in the north lake and eastward in the central lake. Encroachment of the talus had demolished the west cone. The valley floors were now sloping inward at high angles, those at the margins of the northwest chasm and the southwest pond keeping fairly horizontal. Enormous crevasses and outward leaning bench slabs between them created a very unstable condition between the outer walls and the sinking lava column and incessant crashing tumbles echoed in the cracks and formed talus below. The southeast shelf undermined by slides on both sides and with the widening old wall crack behind it became precarious as a place for spectators and many rock falls took place from its overhanging cliff into the liquid pool below. This cliff was now more than twice as high above the lake as the summit of the east ledge. In the evening the southeast shelf had crumbled all the way back to the old wall crack.

On April 2 the following record shows the progress of avalanching:

12:50 p. m., avalanche west wall, great activity north pools;

1:10 p. m., heavy avalanche north for 10 minutes, carrying down blocks 20 feet in diameter;

1:25 p. m., continuous avalanches southeast;

1:40 p. m., slides for 10 minutes under the east shelter, carrying down enormous red hot bowlders;

1:50 p. m., former southeast cove cut off as a pond by avalanche talus; some blocks 20 to 30 feet long;

2:15 p. m., inspection from southeast showed that nearly everything of the February overflow bench from the southeast side of the pit to the northeast fill had gone in, leaving the pit margin on that side essentially as of old, except for the new filling northeast, and overflow veneer southeast.

3:50 p. m., earthquake felt and slides loosened on all sides.

4:15 p. m., whole block of new bench fell just east of south cone, sending up a brown dust cloud;

4:17 p. m., block of southwest crag fell into channel, started violent fountaining which continued for an hour and more and reversed the streaming from the central region so that a continuous torrent poured westward to a place of violent bubble fountaining at the southwest bend.

From under the northeast fill just west of the east shelter and 15 feet down, aa lava was trickling out with a flaking motion very slowly.

4:20 p. m., lake rapidly sinking, showing bright rim and overhang 6 feet high. The southeast cove pond, dammed off from the main lake, did not take part in the sinking. Streaming westward from the southeast arm. While the lake sank thus the avalanches were quiet.

4:57 p. m., earthquake shock and more slides.

The depression of the lake at 3:30 p. m. was about 130 feet. There were six ponds, four north and northwest, the main lake and the southeast cove pond. The central steeple was lower than the central crag summit and the crag and bench surfaces indicated a tilt southeastward as though the subsidence were faster in that direction. The northwest crag was now buried under talus like the southeast channel.

On April 3 at 7 p. m. measurement made the lake 238 feet below the east shelter and the summit of the central crag 130 feet down. Eighteen fountains in action at fixed places were building spatter cones, while extensive floors and overflowing margins showed that the lakes were rising relative to the crags. The pools were mostly crusted, and streaming showed no fixed directions. The central region of the lake was widened northwestward, the southeast arm northeastward and the north pools both westward and eastward. Avalanching was dominantly from the faces of the northeast fill and the west niche where the incandescent lava seen on the previous day to be aa flaked off on the face of the wall, undermined everything above and so produced tremendous glowing falls of most spectacular aspect. The material appeared like banks of glowing coal. The talus would slide in incandescent streams and the cliff faces glowed red above the whole length of the former 1894 bench and the west niche bench.

Glowing spots on the face of the southeast cliff, bright red glow in cracks only a foot down on the new overflow 30 feet back from the southeast edge, and rise in the ground-temperature there, very marked during these days of subsidence, all suggested that fresh oxidation was started in the flow material beneath by exposing it to the air at the new cross section of the broken pit wall.

On April 5 at 4:30 p. m. the avalanches were few and small, fresh lava had flooded the depression east of the central crags, the northeast cove area and the northern and western pond shores and there was high gas pressure from the many blowing and fountaining cones.

On Friday, April 5, measurement at 9:15 a. m., made the depression of the lake 237 feet and of the central crag 129 feet below the east shelter, showing that subsidence had ceased. There were a few dust slides but no avalanches. Some tumbles from the east island mass and the south pressure ridge suggested rising motion in the crags. The lakes were flush with the new overflow benches, driblet flows were pushing out in the central region, all the lakes were increased by marginal building and strong blowing noises came from the center and the west chasm. Fresh overflow had poured across the west end of the southeast crag remnant from the southeast arm to the southeast pond.

The central pond had a large dome stained yellow and with a dark cavity in its summit. There was another large cone in the central floor. At the lake shore on the east side of the southwest bend there was inflow under the bank at a spatter cone and an enormous periodic fountain would explode here about once in 45 seconds like the former "Old Faithful." Relative to the central crag benches the lake appeared 15 feet higher than two days before. The talus on all sides had settled down leaving smooth walls, one large surface southwest showing vertical scorings. The former valley floors south and west now stood upright as nearly vertical slabs. Of the upturned pressure edge of the old pit wall southwest little remains, as that material caved away when the lava went down.

There was much local earthquaking during the subsidence, which ceased when the lava turned, and there was very pronounced tilt to the west and south, which changed to slow recovery east and north when the lava began to rise. The report of the Whitney Laboratory will otherwise be deferred.

VOLCANO OBSERVATORY, April 13, 1918.—During the week ending Friday, April 12, 1918, the Halemaumau lava column continued its recovery and rose some 30 feet, lifting the whole body of floor and crags by that amount until April 8. After that date subsidence was resumed until the morning of April 12 so that at the end of the week the lava was about as low as at the beginning. It now appears to be recovering. The only marked changes are further collapses of remnant benches of new lava which clung to the rim of the pit, new interior floors from overflow of the lakes, and considerable falling away of the central crag mass so as nearly to destroy its eastern steeple.

At 10:30 a. m. on Saturday, April 6, the lakes were strongly rising at a faster rate than the crags so that new overflows made new floors in all directions. There were five ponds of liquid lava as follows: (1) the main lake from southwest arm to southeast arm; (2) the north lake including both the north and northwest former coves; (3) southwest pond; (4) southeast pond; (5) the west chasm pond. In addition the crusted depression of the central pond really contained a lava pot beneath, but it was now roofed with bronzy flows and had a large hissing cone in its center stained with whitish sublimates.

The streaming was north in the north lake and east in the southwest and main lakes. There was a row of grotto cones along the northwest side of the southeast pond and one large cone on the opposite side. There were about eighteen fountaining border cones in the other lakes, occasional central fountains would break the crust and at the west end of the main lake the rhythmic fountain would occasionally explode. The channel here leading to the southwest pond was choked by falls of debris. So high was the construction by overflow that the northern peaks of the east island mass were entirely isolated, back of this mass the flows of the east and northeast coves had merged, the eastern crags of the west crag mass were nearly buried, the western deck of the central crag mass was only a few feet above the lake level, the southeastern flows were all merging and the southeast crag remnant was almost entirely submerged. The overflows of the north lake showed signs of joining through to the west chasm pond and the new floods lapped against the outer debris slopes of the pit on the west, northwest, north, southeast and southwest. There were large cones at each of the two eastern coves of the lake. The noises were of fountaining and putting, there were occasional small adjustments of the high talus and the fume was somewhat diminished. At noon a glow edge of subsidence appeared about one foot deep around all the lakes except the southeast pond, but the latter rose and overflowed on all sides for some time before it, too, cracked up and subsided.

On April 8 at noon measurement made the depression of the summit of the central crag below the east station 103 feet and of the liquid lava in the center of the pit 198 feet. The bench magma appeared to have risen in relation to the lakes and the margins of the latter were higher towards the west and progressively lower eastward and southward. Thus the rims of the southeast pond and of the southern overflow margin of the southwest pond were only one foot high while the enclosing banks

of the main lake varied from two feet high on the east to five feet high on the west. The northwest pond was again defined as a small pit of live lava with walls six feet above the liquid, and radial flows made new floor all about it. The north and west lakes were merely floors of new flows, the former being represented by a high hissing spiracle cone at the base of the cliff made by the north smoke crag. The southwest arm was again connected through to the southwest pond. The central pond cone was hissing and the southeast pond exhibited a blowing and spraying grotto.

At 6 p. m. on Thursday, April 9, after a very rainy day, the lakes appeared somewhat lower, there were more open pools, fume was increased and a small local earthquake felt during the previous night accorded with these symptoms in showing renewed subsidence. The southeast pond was crusted over within margins three feet high and two spraying vents on the north side were made by gases escaping from under the crust. The southwest pond was crusted over. Eastward streaming in the main lake carried along polygonal crusts to be engulfed at several active grottoes at the east end. There were fewer of these than a few days earlier. The southeast arm was extended eastward. There was a flaming and hissing cone on the east cove floor and another one with glowing flanks in the north central region. At the northeast cove there was a fountaining pot, and an open pool at the north pond showed three fountaining grottoes opening eastward. The lake appeared lower in the central region.

On Wednesday, April 10, at 10:30 a. m., the inner pits of the active pools were deeper, having five foot walls at the southeast pond and east arm. The entire summit block of the central steeple had fallen away on both the north and south sides leaving much talus beneath. The east arm of the lake had broken back to the east cove dome where there was inward streaming and fountaining; three fountains played on other sides of the southeast arm and two fountains north and northeast of the southeast pond. At the northeast cove there was a small open pot, much fume rose from the floors, streaming was outward from the southwest pond, all the lakes were crusted, with occasional cracking and foundering and the floor margin of the main lake appeared much increased in height westward. From 12 noon to 1 p. m. the northwest pond overflowed strongly, the flood extending itself some 300 feet along the base of the west talus. During a temporary subsidence a cavern was revealed under the southwest margin of the pond. In the north central floor there was a small open pot showing lava five feet down and farther south was a fuming vent. There was slight glow of the east side of the west chasm pond which was otherwise crusted over. The rhythmic fountain at the southwest bend still erupted every forty seconds. The bank of the main lake appeared highest in the central region. The hanging pinnacle of the central crag was still in place. White fumes still continued to raise from the south cone which makes an eminence on the southern margin of the pit.

On April 11 at 4 p. m. sharp subsidence was in progress, the inner pits were 20 feet deep and avalanches were falling around the outer walls of the main pit on all sides. At 7:30 p. m. the liquid lava appeared still lower and showed increased activity while the avalanches continued to fall. The tumbles from the new northeastern and western fills showed no incandescence.

On Friday, April 12, at 4 p. m., measurement made the depression of the central crag beneath the east station 136 feet, of the central floor bench 236 feet, and of the lake 15 feet lower. The pit was very smoky, the inner lake pits 15 feet deep towards the east and 20 feet towards the west. Both lakes and crags had greatly subsided. The activity was dull, streaming was eastward at the southwest bend, the rhythmic fountain there was smaller and showed somewhat shorter intervals, the lakes elsewhere were mostly crusted over. No avalanches were falling and the lake magma appeared to be rising. The talus summits on all sides were lower and the wall spaces above them higher. Large blocks of the March bench had fallen away from the high edge of the pit east, northeast, north and west, and there was now very little left of such new benches. The northwest triangu-

lation station had fallen to a small remnant bench just beneath. There was a deep indentation in the north side of the central crag mass and only the eastern end of the steeple there remained. The poised pinnacle, however, was still in place.

The seismographs have recorded little earthquake activity, tilting to the west and south has been resumed, volcanic vibrations and microseisms have somewhat increased.

VOLCANO OBSERVATORY, April 20, 1918.—During the week ending April 19, 1918, the lava column has maintained a depression oscillating near the 225-foot mark for the main lava lake, the adjustments for the week being subsidences of the central crags and floors and irregular risings of the lava pools so as to overflow the floors in different places on different days. The net effect is new construction of floors at the expense of crags and talus. Thus on different days the measurement of vertical angles showed the following:

April 14, lake and floor higher, central crag lower.

April 15, lake lower, central crag and floor higher.

April 16, lake higher and overflowing, central crag and floor lower.

April 17, lake, crag and floor lower.

April 19, lake, crag and floor higher, (lake overflowing.)

On Saturday, April 13, at 2:30 p. m., the lakes were quiet and the smoke thick. The margin of the east arm pool was 10 feet high and of the southeast pond 20 feet high. Little could be seen towards the north, the ponds and floors appeared indistinguishable and puffing could be heard towards the west. For over an hour there were no slides. At 3:40 p. m., however, a strong avalanche started on the northeast wall and this was followed by others north and northwest. At the same time the southeast arm developed fountains and subsidence, indicating the close sympathy that exists between rock-sliding and lowering of the liquid lava.

On April 14 at 11 a. m. the southeast pond was somewhat higher with walls only 12 feet high, while the inner pit of the east arm remained about 10 feet deep. Rocks were sliding on the north and west, there was the occasional noise of a sharp gas blast toward the north, three border fountains played in the east arm and one or two in the southeast pond. The lake appeared to be rising but the pit was excessively smoky, especially from the north vents. The central crag pinnacle was still in place and has remained so throughout the week.

The rhythmic fountain at the west end of the main lake exploded at intervals of from 25 to 40 seconds, with sometimes a secondary explosion 10 seconds later. The fountaining took the form of an immense dome 20 feet in diameter which completely filled a caldron of the same size and at 11:40 a. m. the east wall of this cauldron caved in, producing violent turbulence and much noise. The southwest pond had become triangular and a narrow gorge containing a bridge of crust separated it from the fountaining cove. The wall around the southwest pond was 20 feet high and bench levels in general sloped strongly downward from here to the central region. There was a hissing and flaming cone in the north central floor. The northwest pond was active and there was an open pot two feet in diameter on the east side of the west pond.

The long northeast crag mass now appeared low compared with the other crags and the new flood floor north and northeast was becoming a center of accumulation which seems to go with this northeastern subsidence and the southwestern uptilting. Thus the old west crag mass had distinctly lifted the new spatter benches of the west chasm pond on its east side while the remainder of the floor of that pond sloped gently eastward. The upper surface of the west crag mass also sloped eastward.

There were small avalanches from the outer wall of the pit on all sides. Narrow remnants of the 1918 new lava still clung as benches near the upper rim of the pit under the northwest and west stations about six feet below the edge. Under the west niche a large upright block of the new bench hung out into the pit in a precarious position. At 4:30 p. m. there were slides northeast and east, some large bowlders rolling down the slope. At this time the lakes were quiet, the only active grotto being in the east cove.

On Monday, April 15, at 5:15 p. m.,

there were fewer avalanches, streaming was eastward, the central pond cone was glowing and the banks of the eastern pools were 10 feet high. Crusts broke up and foundered in the southwest pond, the west pond was crusted over and only glowing spots could be seen towards the north where the smoke was excessive. The rhythmic fountain was erupting weakly. Examination of the southwest margin of Halemaumau showed from familiar landmarks that this edge had caved back recently fully 15 feet as compared with conditions before the overflow.

On April 16 at noon, a remarkable adjustment of lake magma and bench magma was taking place, whereby the central group of crags and floors had definitely subsided since the preceding day, but the lake had just as definitely risen so that the situation was just the reverse of the intumescence or swelling of the bench magma which was so noticeable in January. The relative heights of shore lines showed how the middle had gone down. The southeast pond was 10 feet down, the east arm pool 5 feet down, while the central lake was only 2 feet down. Going farther west the southwest arm again showed a higher shore line and the southwest pond was more than 10 feet down. This all indicated subsidence of shore lines towards the center of the pit, where also there was extensive fresh overflow which radiated only from the center region. These central overflows were extensive, just as previously the northern ones had been. The lake was puffing and plashing, with new driblet cones formed and eastward streaming. The southeast pond was crusted over but an occasional rush of gas broke the crust and produced a fountain on its south side. The northwest pond was fountaining on its west margin. The main lake in its rising had become constricted and divided into pools with arches of crust between them, and the central channel was greatly narrowed.

At 12:30 p. m. the lake subsided, there was a prolonged avalanche towards the north, occasional slides were heard elsewhere and there was some tumbling of debris from the central crag. Smoke rose from several fissure lines in the northern and central floors, from the north and east crags, the central pond floor and from a wall vent at the top of the north talus.

At noon on April 17 measurements made the central pool and overflows 220 feet below the east station on the rim of Halemaumau at the stone shelter. The southeast pond was 10 feet lower than the main lake. The central crag summit was 152 feet below the rim and hence 68 feet high above its north base; its position was 25 feet farther north than in February. In like fashion the southeast pond was farther toward the center than the former southeast cove of which it was the successor. The old west crag summit was farther south than formerly and 190 feet below the rim, 30 feet above the central floor.

On this day appearances remained much the same but subsidence was dominant and avalanches were falling on all sides. Red dust slid into the smoke-hole half way up the north wall. The top of the lava column was subsiding as a whole, but the lake was brimming level with its margin in the central region and showed fresh overflows, while the northwest pond, the east arm and the western pools were from two to three feet beneath their margins, the southeast pond still more and the southwest pond deepest as to its marginal wall.

There were now identifiable seven pools of liquid lava; southeast, southwest, east, center, west, north and northwest. In addition there were the crusted depressions of the west and central ponds, both definite lava wells beneath. The north pool was a rather deep crack-like depression showing live lava within, and the northwest pond a shallower oval crusted oven. Blowing noise could be heard in this region. The rhythmic fountain in the west pool of the main lake was now nearly buried under crust from beneath which smothered explosions occasionally were seen. There was a glowing chimney above. The poised slab under the west niche had settled into a symmetrical upright unit parallel with the wall plane above, with crevasses on its sides, and wholly breaking the continuity of the otherwise rather continuous funnel slopes of the outer wall of the pit.

On April 18 at 4:40 p. m. there was much fountaining activity. In the southeast pond the margin was 5 feet

Feb. 22, 1918. The day before overflow, SE rim of Halemaumau; the small dome is at the lake edge.—*Photo. Jaggar.*

March 23, 1918. SW rim of Halemaumau, showing upward mashing of old edge of pit; fresh flows in foreground. The SW trig station was lifted 15 feet on the distant hump, center of picture.—*Photo. Jaggar.*

high and a few fountains broke at the edges. In the east arm streaming eastward was swift from the bridge of crust at the central channel. There were fountains at the north but the fumes were thick there. At 5:30 p. m. a noisy slide developed on the northeast talus and some smaller ones at the west. At 6 p. m. the main lake, divided into three separate ponds with bridges of crust between, showed numerous small marginal spatter grottoes building.

On Friday, April 19, at 11 a. m. and thereafter, the east arm was overflowing on all sides, there were many marginal spatter cones, much hissing noise, several filagree glowing cones and about ten fountains in all. Everything indicated strong gas pressure and rising liquid. Streaming was eastward in the main lake and southwest pond. The overflowing of the east arm was followed by similar rising and overflowing of the southeast pond, and lastly the southwest pond rose until it was only from one to two feet below its eastern and southern banks. A spouting cone had been built over the south tunnel on its southeast bank. The hole in the central pond cone appeared dark by daylight. The flood from the east arm finally poured northward through the gap on the northeast side of the east island mass. There were other fresh flows from the northern pools on the north central floor and glowing cracks could be seen beyond. About noon the lakes were rising and falling at the usual intervals of gas inflation. When the first of the temporary subsidences of the east arm took place, the southeast pond lagged behind it about 10 minutes before it, too, subsided. The subsidence amounted to about one foot.

Seventeen fume vents could be counted including wall chimneys on the north, southwest and southeast. Only two slides were seen, one in the southeast talus and another on the southwest side of the central crag.

At 8 p. m. there were many flames, puffing border grottoes, filagree cones and much spurting from under marginal crusts. The high gas pressure continued and the clear seeing gave evidence of much thinner fumes on this day. The lakes in the evening were lower than in the morning, some 5 feet below their margins and there were occasional collapses of the central channel arch. The central pond cone was glowing, flaming and spurting lava. Large banners of flame played above the grottoes of the southeast pond and the east cove and from a long crack in a cone at the north pond. Streaming was eastward, there was much rumbling, there was very little glow on the fume cloud above and the slides were trivial. The fresh floor flows showed glowing cracks. No open pools were seen at the north and no fountaining at the west arm locality, but there was a high flaming chimney there. The west chasm pond was glowing. No glow could be seen from the north wall chimney. The southeast pond had assumed hexagonal form within its new inner bench.

An interesting development at the south cone on the high margin of Halemaumau is the revelation of its interior by collapse. The roof has so fallen in as to show an open chamber some 6 feet high inside with typical cavern stalactites of the wormy type on its ceiling. As these were formed within a hot gas chamber source of active lavas less than a month ago, the proof is conclusive that such stalactites are not formed by water drip, but rather by refusion of the ceiling lava. The interior of this chamber was full of scalding vapor and too hot to explore, but from the entrance a large tube could be seen leading southward under the high pressure ridge and domes of the new overflows of March.

The following is the report of the Whitney Laboratory of Seismology for the three weeks beginning at 2 p. m. Friday, March 29, and ending at 2 p. m. Friday, April 19, 1918:

For the week of sharp subsidence of the Halemaumau lava ending April 5, forty-one local earthquakes were registered, most of these occurring March 30 to April 3.

There were fifteen shocks March 30 as follows:

3:52 a. m.	12:03 p. m.	11:16 p.m.
5:45 "	1:27 "	11:27 "
6:02 "	6:15 "	11:38 "
6:20 "	7:46 "	
7:07 " (felt)	8:23 "	
11:37 "	10:55 "	

On March 31 there were three shocks respectively 2:42 a. m., 9:43 a. m. (felt), and 5:39 p. m. On April 1 there

were three shocks, 3:54 a. m., 7:06 p. m. and 7:07 p. m. (felt ?), and other slow jarrings. On April 2 there were thirteen shocks:

a. m.	p. m.	p. m.	p. m.	p. m.
12:30	3:19 (felt)	5:47 (felt)	8:15	11:28
4:53	3:49	6:46	8:31	
5:54	4:58	7:31	9:44 (felt)	

On April 3 there were five shocks, all a. m. 12:05, 1:18, 2:36, 3:19, 7:54 (felt). On April 4 there were two very slight tremors at 9:33 p. m. and 9:35 p. m.

During this week the tilting became excessive to the west and very strong to the south, microseisms were moderate and there were many spasms of volcanic vibration.

During the week ending April 12 there were only two local earthquakes, one small tremor at 6:31 a. m., April 7, and a shock at 11:10 p. m., April 8. The strong tilt to the west and south continued with fluctuations, microseisms were moderate to strong and volcanic vibration decreased.

During the present week ending April 19 there was one local tremor at 5:10 a. m., April 14, and one weakly recorded teleseism beginning 8:29 p. m., April 16, the trace of which could be detected on the seismogram for about five minutes. The record gave no indication of distance of origin. During this week the westward tilt decreased and then showed stationary tendency while the southward component fluctuated somewhat with general tendency to decrease. Microseisms somewhat increased and volcanic vibration was moderate.

VOLCANO OBSERVATORY, April 27, 1918.—During the week ending Friday, April 26, 1918, very strong rising of the lava column of Halemaumau has been in evidence with extensive flooding by lake overflow on the east side of the bottom area, and a responsive rising of the central and western crags following upon the overweighting towards the east.

Taking the lake at the central channel and the summit of the central crag as datum points, the following shows the sequence:

April 18-20, (three days), lake rose 24 feet, crag 3 feet.

April 21-23, (three days), lake rose 11 feet, crag 18 feet.

April 24-25, (two days), lake rose 5 feet, crag 7 feet.

April 26, (one day), lake rose 6 feet, crag 0 feet.

It will be seen that the movements of the crag lagged two or three days behind those of the lake and this has been usual in the past. The bench magma movements are apt to be tilting or central upswellings preceded by a gush of lake magma and high gas pressure. Furthermore the rising spell as a whole showed the following rates:

April 18-20, (lake 8 feet per day, crag 1 foot per day.

April 21-23, lake 3.6 feet per day, crag 6 feet per day.

April 24-25, lake 2.5 feet per day, crag 3.5 feet per day.

April 26, lake 6 feet per day, crag 0 feet per day.

This shows culmination for the lake April 19, and for the crag April 22. It will be seen that a renewed spasm of rising for the lake April 26 should be followed by a similar spurt for the crag and this has since happened, the end of the week exhibiting very strong rising. On April 20 the relief of the crag above the lake reached its minimum of 47 feet, but on April 26 the crag stood 50 feet above the lake, showing that its net rise during the week was greater than that of the lake.

On Saturday, April 20, at 9:45 a. m., the depression of the lake was 196 feet. The pit was more fumy with lake margins three to four feet high, fountaining, streaming and puffing, marking continued gas pressure, the appearance of lower lake magma probably due to uplift of bench magma. At noon there were strong overflows as on the previous day. One or two small rock slides were heard. The southeast pond had developed, within its inner floor by building inward, a striking hexagonal plan with rounded angles. It was in process of more and more constriction from a pond to a pot. At 3 p. m. the lake shores were five feet high. There was strong puffing to the north, a large central fountain was playing and several small ones; rock slides were occasionally seen. At 2:30 p. m. the southwest pond showed four fountains and was level with its southern bank. At

4 p. m. an unusually strong rock slide was heard toward the northwest.

On April 21 at 4:30 p. m. the southeast pond was overflowing and continued to do so for an hour, then the lava sank about four feet, leaving the pond much smaller, some 25 feet in diameter. The east arm was quiet and brimming level with its banks and when the subsidence period came it broke up and numerous fountains developed there and in the central region. The northern cones were puffing strongly and a small slide took place southwest.

Measurement on April 23 in the morning made the lake depression 185 feet. In the east arm the liquid was two feet below the margin, in the center five feet below and more farther west. At the east end were fresh overflows, a puffing filagree cone and spatter cones in process of construction, and others were forming in the central region. There were glowing heaps in the north central floor and at the north pond site, the latter hissing harshly. There was much growth of the floors and the east island remnant was nearly buried under them. The valley between the northeast crag mass and the wall of the pit was now below the floor levels and liable to invasion by flows as soon as the inner construction overtopped the lower portions of the northeast crag mass. The southeast pond region was all covered by new flows and the pond itself had become a narrow pot showing the liquid lava five feet down. A very small slide southeast was heard. The central channel was again open making one long river-like pool and streaming was eastward from under a bridge of crust over a tunnel leading from the west arm to the center. Rhythmic fountaining had ceased at the western cove. No open pools were visible north or northwest. The central and western crags appeared rising while the eastern features sank.

Measurement at 10 a. m. on Thursday, April 25, 1918, made the lake depression 180 feet. The southeast pot was still smaller. The lake was below the marginal floor three feet at the east, six feet at the center and ten feet at the west, showing that the whole floor block or crust surface of the bench magma column was being depressed at the east and lifted at the west. There were large fresh flows from the east end of the lake which had poured along the southwestern base of the northeast crag mass, showing that there was depression there. There were other fresh overflows along the base of the northern and northwestern talus, from the west pond and from the south side of the southwest pond. A wide new bench was built along the north base of the central crag mass and the fresh floor lapped high up the east base of the west crag mass. The central pond cone was half buried under new flows. On this day and the next the fume from the pit was thinner but fluctuated strongly in density within short intervals.

At 4:30 p. m. the edge of the east arm was only one foot high and the lake was quiet until 5:45, when subsidence took place for half an hour, the liquid lowering about six feet and developing the usual activity. The southeast pond site showed only small glowing apertures. Slides were few and small.

At noon April 26 the lake depression was 174 feet and the summit of the central crag was 124 feet below the rim at the east shelter. High gas pressure with rising and overflowing lakes continued. The several ponds were now mostly crusted over with surfaces continuous with the great floor area, excepting the southwest pond and the long stretch of main lake from the western to the eastern arm. The southeast pot was totally arched over during the morning by the construction of a high blowing cone over its grotto, with an open hole at the base of the cone. Streaming was eastward in the main lake, there was occasional breaking up with central fountaining, and marginal grottoes were active at the east end, on the north and south sides of the east arm and on the north and south sides of the central region. There was a glowing heap on the north central floor and at the north pond site under the north smoke crag a high stack was building. This had a circular hole some two feet in diameter across its summit and explosions inside at irregular intervals flung up an umbrella of melt. There was a bell-like ringing noise from the structure and the detonation was a muffled report like the exhaust of an

explosion engine and not like the mere escape of confined gas. The noise implied a true chemical explosion of gases mixed with air and ignited. The stack at this time was over 10 feet high and quite slender.

The other cones were blowing strongly. The lake shore was two feet high east and ten feet high west. The western bridge of crust was more slender and there was violent fountaining in the west arm. The overflow pattern east and southeast was new and a wide floor of fresh overflow had built west and south of the southwest pond which was active. Rainfall produced dense steam clouds from the floors showing their high temperature. At noon rising was in progress. Much fresh flow material could be seen dimly in the northwest pond region.

In the Whitney Laboratory of Seismology during the week ending at 2 p. m. Friday, April 26, two local earthquakes have been registered respectively at 7:02 p. m., April 19, and 1:25 p. m., April 21. A teleseism identifiable as the one reported disastrous in southern California was registered at about 12:19 p. m. April 21. Microseisms have decreased from very strong to moderate and volcanic vibration has fluctuated slightly with moderate values. Movement of tilting has been steadily progressing with inclination to the east-southeast.

VOLCANO OBSERVATORY, May 4, 1918.—During the week ending May 3, 1918, the lava column has continued to rise at Kilauea, the lakes and crags continuing to alternate in their spurts upward, the ones even subsiding slightly on the days when the others rose. The sequence was as follows:

April 26-28, lake rose 5 feet (depression 174 to 169 feet); crag rose 13 feet (depression 124 to 111 feet).

April 29-30, lake rose 10 feet (depression 169 to 159 feet); crag sank 5 feet (depression 111 to 116 feet).

May 1, lake sank 4 feet (depression 159 to 163 feet); crag rose 5 feet (depression 116 to 111 feet).

The changes of the week have been similar to those of the week before, the lava floods so extending the floor area as to surround all the crags and lap the base of the talus, making an octagonal flat surface above which the crag remnants stand in relief. Three of the crags which were conspicuous objects at the time of the March subsidence have completely disappeared, buried up under talus and lava floods. These are the southeast, northwest and east island crags. The new flows have poured across and buried the east ledge and made a new ponded filling of the northeast valley. This process has now happened four times within the last fifteen months.

On Saturday, April 27, at 3:30 p. m., the inner bank of the east pool was four feet high and at the west arm much higher. The activity was sluggish and the pools crusted over with a rising tendency while spurting fountains broke from under marginal crusts. The southeast cone occasionally hissed and there was much puffing to the north and west.

When the circuit of the pit by way of the east and north rims was made flows were seen pushing across the northwestern and western floors from vents which exhibited high gas pressure at the northwest and west ponds. The north stack, formed on the previous day, was 20 feet high and now inactive. There was a flaming cone in the north central floor. Streaming was at first eastward in the central channel and the southwest pond, and westward in the west arm.

At 5 p. m. the east arm started overflowing, at 8 p. m. the southeast cone broke open and threw up a high standing fountain as the source of extensive flows, and at 9:30 p. m. the southeast pond was overflowing strongly.

The east arm overflows increased in volume from 5 to 7 p. m. with very strong spurts, so that two heavy streams were developed which poured north and south from the east end of the pool, the latter becoming covered with quiet crusts.

A sudden marked increase at the end of the first half hour of steady overflow, and at the same time the lake from the central channel westward exhibiting a glowing rim of overhang as though sinking, while the same lake in the east arm filled its basin to the brim and overflowed in strong pulsations, all gave evidence which checked with the greater height of banks westward, to the effect that the whole bench magma

surface was tilting downward on the east side and upward on the west about an axial line in the narrow. At the same time there was strong cracking of crusts and fountaining in the central and western regions. The central crag summit measurably rose during the afternoon, this being a part of the western uplifted half. As the overflows shifted from (1) west to (2) north, then (3) east and southeast, and (4) southwest, it is probable that the disk of bench magma constituting the circular upper crust of the lava column, including all crags and floors, executed a somewhat spiral tilting movement as the weighting of the overflows spread in the sequence indicted. These overflows were now around the margins in contrast to the central floods of a few days before.

The eastern overflows filled the whole southeastern part of the pit surrounding the southeast cone elevation; the accumulation stagnated in the east central region and deepened until it overflowed the low saddle in the middle of the northeast crag mass. Two narrow molten streams poured down the back slope of that mass into the northeast valley and reached the foot of the talus.

The southeast cone fountain shot up 20 to 30 feet like an artesian well and continued for hours, the column lowering and the pool around it rising so that the former central pond was obliterated and the whole area east of the central crag mass ponded level with the lake surface. The southwest pond poured over its western and southern margins profusely.

Flames were abundant at the southeast cone and two glowing cones on the north central and northeastern floors. Late in the night the southeast fountain built a flaming cone about seven feet high with a spouting pot in its summit.

Near the northwest pond locality a blowing cone developed and made explosive detonations similar to the stack of the previous day and flung up umbrella-shaped blobs of melt. The growth of a driblet edifice here finally deflected the spurtings from vertical to 45° northeastward, and still later the jets were being ejected almost horizontally through the building up of a pipe which confined the blast and expelled it laterally.

Occasional fountaining was seen in the west pond and fresh floods of lava were pouring over the northwestern floor. The fume became very thin and the spectacle on this evening was magnificent. The noises were those of strong gas pressure. The only talus adjustments were small ones due to the shiftings of the bench magma.

On the morning of April 28 overflowing was still in progress southeast, and new flows had increased the bulk of the two streams on the back slope of the northeast crag mass. At 5 p. m. it was evident that overflowing continued without abatement, the floods being everywhere pooled so that toes pushed out around their margins, especially northwest and southeast. The same hissing and spurting were everywhere in progress. The following were source vents: (1) the southeast pond, (2) the northern cones, (3) the west pond and (4) the circular pot at the west bend which until recently was the site of the rhythmic fountain. From this last place the streaming was northward in the west arm and eastward in the southwest pond. The main lake was flush with its banks in the east arm and probably overflowing beneath the crusts which marked its margin. The southeast cone was a center for V-shaped glowing areas which marked flows radiating from it. The flow levels were slowly rising around the north stack.

On Monday, April 29, 1918, at 11 a. m., the gas pressure was somewhat less but the lakes were still high. There were fresh overflows on the northeast floor from the north, on the southeast floor from an oven at the southeast cone and still others from the east arm which had built a hissing filagree cone at its east end. There were other such cones southeast and north, glowing lava could be seen at the northwest pond, the northwest pond, the north stack was still standing and the strongest puffing was somewhere in that direction. The banks at the southwest pond were one foot high, at the east arm three feet. At 1 p. m. vigorous overflow began at the southwest corner of the east arm and the southwest pond appeared ready to overflow at its south margin. Both

of these pools showed a lift of shorelines in the direction of the west arm. A few rock slides occurred during the morning.

The new floor surfaces were now three crescent-shaped plains which with continued growth promised to join at their horns so as to completely encircle the crags. The three crescents were northwest, east and southwest and the interruptions to the continuous circle were the junctions with the talus of the north, south and southwest crags. Everywhere the liquid lava was gaining on the crags so that these gaps must soon fill.

On Tuesday, April 30, at 4:30 p. m., it was evident that there had been excessive overflowing at noon. New glowing surfaces which were smooth as from deep pooling extended from around the east arm to the southwest pond and beyond making a new floor through the notch south of the south crag mass. There were other fresh flows west, north and northeast, the latter extending across the former east ledge and making a new floor the whole length of the northeast valley. The new flows lapped the talus under the walls of the pit everywhere except on the north and southwest.

Hissing was strong from glowing heaps southeast, east and north. There was glow at the northwest pond site and the north stack was still in place. Some rock slipping was heard. The lake margins were three feet high except for the central pool, which was somewhat higher. The former central pond was now obliterated under a flat floor and only a glowing heap of crust marked the site of the southeast pond. The southwest pond was more constricted and rounder. The west bridge was again wide.

On Wednesday, May 1, at 11:30 a. m., the floor was built still higher and the two ridges on the north and southwest which interrupted the continuous circle of new flows at the base of the talus were now flooded. A cascade had poured through from under the north station into the northeast valley and another from the west pond to the southwest floor. On this morning a standing fountain at the west pond sent a flood westward to the talus which pooled right and left, extending to the southwest pond floor and to the extreme north. The north stack now protruded only about five feet. There were new overflows from the main lake and a dome grotto at the northeast end of the east pool was half submerged under new flows. The cone at the east end was new.

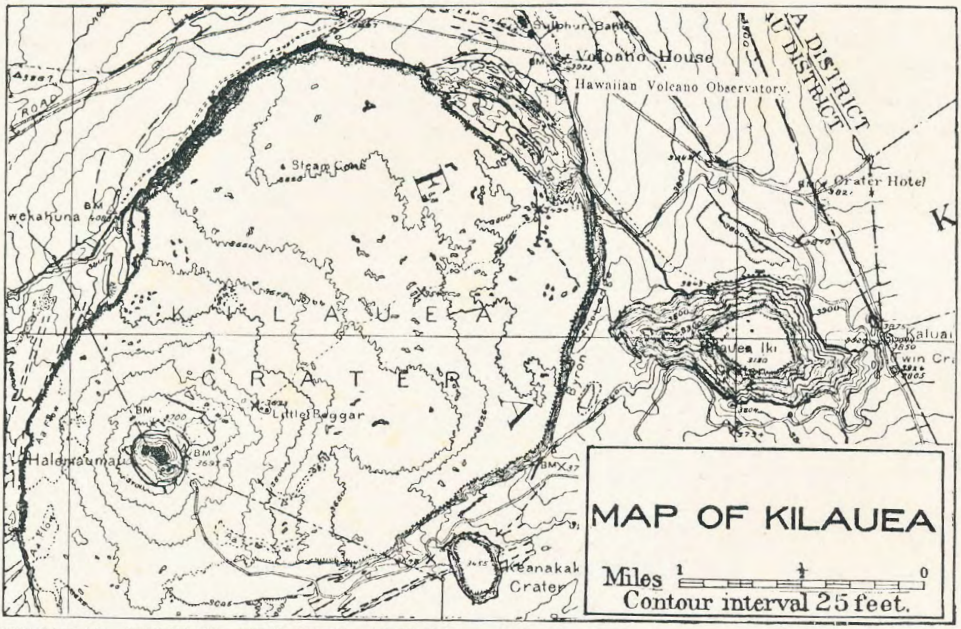
While the west pond was flooding strongly, the lake at 11:30 a. m. showed five-foot margins and the southwest pond was a foot higher. An hour later both the southwest pond and the main lake rose to brimming and the lake overflowed the south margin of the central channel. Both the east and west pools showed banks a foot high at this time indicating that the floor sagged downward in the middle of the pit.

On May 2 at 5 p. m. the inner margin was four feet high at the east arm, there was much fountaining and strong blowing was heard from a cone at the west. At 6 p. m. the main lake was nearly brimming. There was some rock sliding from the southwest wall. On May 3 there were driblet flows which added to the material heaped above the sunken east ledge, but in general the heavy overflowing had ceased.

The instruments of the Whitney Laboratory of Seismology for the week ending at 2 p. m. May 3, 1918, have registered five local earthquakes, the last three being very small ones, and these were simultaneous with the excessive overflows of the Halemaumau floor. The times were 5:17 p. m. April 26, 7:40 p. m. April 28, 7:07 and 9:40 p. m. April 29, and 8:30 a. m. April 30. Microseisms have been moderate, and volcanic vibration showed occasional intense spasms until April 30, thereafter it was normal. Movement of tilting was stationary or fluctuating until April 28; thereafter it became pronounced to the east with fluctuation in the north-south component.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. All scientific exchanges should be sent to this address.

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

	Expressed by accelerations measured in millimeters per second per second.		
I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the accceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, MAY, 1918 No. 5

HAWAIIAN VOLCANO OBSERVATORY, May 11, 1918.—During the week ending May 10, 1918, the lava has risen rather continuously in Halemaumau, so far as measurement of the position of the central crag is concerned, though the lake in its inner depression has had the appearance of being low and the bench magma has distinctly risen at times while the lake magma has subsided.

The following shows the progress of events whereby the central crag and the lake, as before, have alternated in their pulsations of rising:

Depression below east rim of pit:

May 5, crag summit 93 feet, lake center 166 feet;

May 6, crag summit 91 feet, lake center 159 feet;

May 7, crag summit 90 feet, lake center 166 feet;

May 8, crag summit 86 feet, lake center 167 feet;

May 10, crag summit 85 feet, lake center 157 feet.

From May 5 to 10, therefore, five days, the crag rose eight feet, an average of 1.6 feet per day, while the lake rose 9 feet, an average 1.8 feet per day; but from May 6 to 8 the lake was sinking while the crag was rising, the liquid tending to surge up and down in strong pulsations while the stiffer bench magma rose and made slower spurts. The sequence was

May 5 to 6, crag up 2 feet, lake up 7 feet;

May 6 to 7, crag up 1 foot, lake down 7 feet;

May 7 to 8, crag up 4 feet, lake down 1 foot;

May 8 to 10, crag up 1 foot, lake up 10 feet.

Saturday, May 4, 1918, was rainy but the only changes were in the nature of upward warping of the bench magma following the overflows of the previous days. A small flow poured from the southeast cone southeastward and this flow was very liquid and exhibited a glistening, glassy surface. There had been driblet puddles spreading on the northeast floor, probably of the previous day, and fresh short flows across the east ledge.

On May 5 at noon the southeast cone was glowing and puffing and there were other cones at the west pond, on the central and northeastern portions of the northern floor, two small heaps and smoking cracks at the northwest pond site and the remnant of the north stack still stood about five feet high. The banks of the east pool stood 4 feet, the central pool 6 feet, the west arm 10 feet and the southwest pond 2 feet above the liquid. Of the latter the bank of the north side was somewhat higher. The lakes were rising, the east pool was crusted over and cracking around the edges and there was cracking of crusts and bubble fountaining in the central pool. The west bridge separating the central pool from the west arm was narrow and thick with an arch three feet high beneath it. Gas pressure was moderate and there were few fountains. After 1 p. m. streaming eastward developed slowly, seven marginal grottoes showing stalactites were active in the central and eastern pools, and the west arm showed blistered skins and much bubbling. No hissing was heard from the north cones and there was now no trace of lake outlines north or northwest, only a continuous floor.

The central crag was more fallen away on its southeast side and fresh fallen rocks from it lay on the new floor. The pinnacle, part of a slab

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Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

south of it and separated from it by a chasm, tended to lean farther southward. A continuous train of festoons from the west pond northward indicated a last long flow in that direction. A long straight crack, gaping upward, extended from the spatter dome on the southeast edge of the east pool to the southeast talus. This and the rock slides from the central crag showed new motion in the bench magma.

Looking down from the southwest rim of the pit, the radiation of flows and streaming from that corner of the floor was striking. Considering the west pond as a center of upwelling liquid lava the streaming was southeastward in the southwest pond, eastward in the main lake, northward into tunnels of the crusted north arm and northwestward as overflows from the west pond. In the southwest pond there was a fountaining grotto tunnel in the east corner and another at the south corner.

Another striking feature of recent developments southwest was the uplift of the bench magma near this same center of outflows. The south end of the west crag mass and the deck of the central mass were both distinctly lifted.

At 4 p. m. on this day (May 5) the lake was lower relative to its banks, the east pool showed marginal cliffs 10 feet high, there was swift eastward streaming and active fountaining at the grotto under the southeast crack and another farther north. The current forked in the east pool and divided itself to rush under these two places swiftly. At 4:40 p. m. the west bridge collapsed and a few minutes later a large block of the western extension of the central crag mass fell in. At 6:20 p. m. a prolonged slide in the west talus took place and later the roof of the southeastern grotto collapsed and started much fountaining in that corner of the east pool. At this time the lakes were crusted elsewhere. The central pinnacle was still in place.

On Monday, May 6, at 5:30 p. m., both lake and central crag had risen, and the central pinnacle had fallen during the night to a jumble of immense bowlders in the notch south of it. Only its stump remained. The disturbance of the previous evening had evidently been a strong upward adjustment of the bench magma.

There was increased gas pressure, four border fountains were spurting in the main lake and the southeast floor cone was puffing. The southeast crack was more pronounced, smoking and showing glowing walls where the spatter dome had collapsed. The southern adjacent block appeared lifted. Fountains were very active in the tunnel beneath the crack. A large bowlder had fallen from the east talus to the floor on the northern or depressed side of the crack. There was a glowing heap at the lake margin under the north side of the central steeple remnant. Where the bridge had been the west arm was greatly widened. Lava was splashing inside of the northern floor cone. There was increased blue fume at the west pond, along the north central floor and west of the northwest pond site, the fume rising from many small cracks as though the lifting bench magma opened gas chambers beneath.

The southwest pond was overflooding vigorously on its southwest side, extensive moving lava streams extending all the way from the southwest crag (on the west side of the southwest pond) to a point beneath the south station. These overflows were still in motion after 6 p. m., although the main lake was depressed three feet below its margin at the east pool and more than eight feet in the west arm. Evidently the southwest pond well was independently supplied and its lava at a higher level. There were glowing cones at its eastern and southern corners.

At 6 p. m. there was glow in all the

cones, hissing toward the northwest and the lake occasionally broke up, but generally it was crusted. The south bank of the east pool was cracked and fuming.

After this spasm of overflow, inspection of the pit at 4 p. m. on May 7 showed a reaction with depression of both lake and crag and the inner walls were 8 feet high east, 10 feet at the west, while the southwest pond was only 3 feet down and its surface appeared topographically higher than the main lake. Cavernous grottoes were pounding and rumbling under the south and southeast sides of the east pool, while the streaming thither from the west was vigorous and the melt was covered with thin crust which parted along bright lines. The southeast floor cone was large, glowing and puffing. The north pot occasionally entered upon spells of prolonged blowing after accumulation of gas beneath. There was much fume west and southeast, one avalanche was heard toward the south and the floor cracks showed whitish stains.

On the morning of Wednesday, May 8, the lake was somewhat higher, the southeast cone was hissing, the marginal grottoes blowing and rumbling, streaming was eastward with some bubble fountaining and the north pot still glowed. In general the gas pressure was higher, but there were many fuming cracks and one or two rock slips were heard. Large smoking cracks with stained margins had developed in the floor about the places where lakes or pools have recently been, suggesting open chambers below. These places are in a line along the north central region, near the north stack and at the northwest and west pond sites.

On May 9 at 4 p. m. the pit was rather smoky and the lake margins 10 or 12 feet high. The lakes were very quiet. About 5 p. m. breaking up commenced toward the west and spread eastward so that streaming became visible pouring eastward with many fountains and the usual border grottoes.

On Friday, May 10, at 5:30 p. m., the pit presented the same smoky appearance and seemingly low lake, but in reality rising was in progress with the floors and crags lifting more than the liquid. Blowing cones were hissing southeast, east, north and elsewhere. The point of bench on the north side of the lake between the east and central pools was rising more than the opposite shore so that it stood 15 feet above the liquid at the same time that the cliff margin of the east pool was only 5 feet high. Measurement showed that the northeast crag had risen more than the other crags and its motion was indicated by a fall of rocks from the north wall and by the development of a second crack parallel to the long southeast floor crack on the north side of the latter. The streaming was westward in the west arm, southwestward under the bank of the southwest side of the east pool and southward in the southwest pond. Generally the main lake and east pool were crusted over. Gas pressure was moderately strong.

No earthquakes have been registered by the seismographs of the Whitney Laboratory during the week ending at 2 p. m. Friday, May 10, 1918. Microseismic and volcanic vibrations have been normal and moderate. The tilting of the ground was stationary in the east-west component the first half of the week and eastward thereafter, while at right angles to this the tilt was first southward and then northword. The amount of tilting has been moderate, with tendency to strong eastward tilt latterly.

May 18, 1918.—During the week ending Friday, May 17, 1918, the lava lakes, crags and floors of Halemaumau have risen about 20 feet, but as usual this has proceeded by alternation between the rising of the liquid lava and the bench magma respectively. The swelling up of the latter is again occasioning deep crevassing of the overflow floors and this movement during the week has lifted the shores of the east pool so that the inner cliff around the main lake is once more of uniform height.

The surveys yielded the following measurements:

May 10 to 11, central crag rose 4 feet in 1 day to depression 81 feet;

May 11 to 14, central crag rose 6 feet in 3 days to depression 75 feet;

May 14 to 17, central crag rose 11 feet in 3 days to depresion 64 feet.

May 10 to 11, lake sank 2 feet in 1 day to depression 159 feet;

May 11 to 14, lake rose 15 feet in 3 days to depression 144 feet;

May 14 to 17, lake rose 7 feet in 3 days to depression 137 feet.

May 10 to 14, crag rose 2.5 feet per day, lake 4.25 feet per day;

May 14 to 17, crag rose 3.6 feet per day, lake 2.30 feet per day.

On Saturday, May 11, 1918, at 11:30 a. m., the wall of the east pool was 8 feet high, of the central pool 12 feet, of the west arm 15 feet and of the southwest pond 4 feet. Hissing was occasionally heard toward the north and west. The crusted lakes were very quiet. At intervals, however, the grottoes rumbled and the crusts broke up and foundered. The only visible streaming was local into the grottoes or tunnels which lay on the southeast, south, northeast and northwest corners of the east pool, on the north side of the west arm and on the south side of the southwest pond.

At the southeast crack the floor on its north side had slumped and a second parallel crack a few yards farther north showed increased development. A crack of northeast trend cut the new flows where they crossed the middle of the northeast crag mass. The lifted point of bench north of the central channel had sunk back but the crags were higher. The bench magma was lifting faster than the lake magma. This produced considerable changes in the fuming; at 8 a. m. the fume rising from the pit was very thin; at noon the fume came from patches of the floor and was diffused throughout the pit in a blue haze; at 4 p. m. the general fume cloud was quite dense. The lift of bench magma had caused collapse at the flaming cones. A glowing pot had opened beside the southeast cone and the north blow hole appeared more broken.

On May 12 at 4 p. m. the lake was relatively higher, there were a few rock slides towards the northwest and there was the usual activity in the grottoes. On May 13 it was apparent that the lake magma was gaining on the solidified portion.

On Tuesday, May 14, this rising spell culminated in extensive flooded overflows which pooled in a semi-circle all the way around the base of the northern and western talus from the west pond to the northeast valley, where a heavy flow had poured through the gap between the north crag and the wall of the pit. At 6 p. m. all these flows were glowing vividly and appeared to be fed from the northern cones as well as from the west and northwest ponds. All the orifices of the floor of the pit were blowing, spurting and flaming, and the bench surrounding the eastern end of the lake appeared to be rising, for in the east pool strong cracking, foundering and collapse of banks were going on with marginal glow and streaming into the pool from under crust across the central narrows: whereas from this point westward the lake appeared quiet and crusted as though rising. This implied a new tendency whereby the bench magma was lifting towards the east and so reversing its previous habit.

Very large banners of flame played from under the bank at the northeast margin of the east pool. One strong avalanche fell from the north-northeast wall showing movements in the bench magma; a reddish cloud of dust was produced. There were other small slides east and south. The southwest pond stood one foot below its margin, and the edge was a rampart of fresh overflow. The inner cliffs of the main lake were lower than of late, but much higher than the southwest pond; they were four feet high at the east end and from eight to ten feet high in the central region and towards the west. The block subsiding between the two southeast crevasses appeared to have the pattern of a revival of the former southeast channel. Other cracks extended southward on the east side of the southeast cone. This cone was glowing, flaming and hissing and there were other flaming cones on the bench southwest of the east pool, east of the north stack remnant, at the sites of the former northwest, north and north-central ponds and on the south bank of the southwest pond. Smoke rose densely from the north central floor as though collapse might be expected there, but elsewhere the fume was rather thin.

On May 16 at 4:30 p. m. there was swift eastward streaming with several

fountains in action in the main lake and four at the southwest pond. The lake rose somewhat during the next three hours and became quieter. At 6:30 p. m. the lake was crusted over, but occasionally gas would escape violently around the margin, flinging spray to great heights, breaking up the crust and occasionally downward sucking of the fragments into marginal fountains. This was seen at the east end of the main lake and on the south side of the southwest pond. The three principal places of border fountaining in the main lake were at the east end, on the north side of the central crag mass and at the north corner of the central pool. Hissing was heard from the north glow pot and from a border cone south of the southwest pond, and during a spraying outbreak at the east end of the lake there was strong hissing from a glowing crack on the bank.

A new feature, now becoming conspicuous, was the extension of floor cracking, and glow only a foot or two inside of these cracks. The largest of the cracks followed a semi-circular course about half way between the center of the pit and the east talus. This crack began west of the southeast cone which was now a flaming chasm; it passed through this chasm and extended thence to the south side of the east pool. From the north side of this pool it could be followed across the northeast floor through and beyond the north glow pot which was now a high glowing cone. The two southeast cracks extending from the east pool to the southeast talus had enlarged and gaped upward.

The walls around the east pool were 10 feet high and around the central region they were twice that much so that perhaps the concentric cracking may be accounted for by the lift of the central block. The four larger cracks radiating from the east pool suggested tumescence centering under that pool. The southwest pond banks were only 5 feet high. After nightfall there was glow in all the cones and glowing edges of crust could be seen all along the western and northwestern margins of the floor where the fresh flows abutted against the talus. Small V-shaped patches at the north appeared to indicate flows in motion. There was much fume from the north-central and northwestern regions.

At 5 p. m. on Friday, May 17, the southwest pond showed 4-foot margins and the lake 15 to 20-foot margins all around, indicating that the east pool basin had risen to a common level with the central and western basins. The radial cracking around the east pool was very pronounced and the large north crack was extended to beyond the north stack. Blowing could be heard, the lake was crusted over and explosive outbreaks from under marginal crusts had continued. Lava could be seen splashing in the southeast pot.

Evidence that the pit floor was in motion was furnished at 5 p. m. by a prolonged series of avalanches lasting three minutes or more which undermined the wall of the pit just east of the north station and finally carried away a portion of the recent lava of the northeast fill. A pink dust cloud shot up and the northeast valley floor was covered with bowlders and dust.

The instruments of the Whitney Laboratory for the week ending at 2 p. m. May 17, 1918, have registered two strong distant earthquakes. One of these began about 11:12 a. m., May 11, and the preliminary phase, which was very imperfectly registered, suggested a distance of 7600 kilometers, the distance of southern New Zealand or Costa Rica. The second began about 9:13 a. m., May 16, and appeared to be very remote, some 11,500 kilometers, equal to the distance of northern India or the Caspian Sea.

Two very small local tremors were registered at 8:51 p. m., May 12, and 5:26 a. m., May 13. Microseismic motion has been moderate and decreasing. Volcanic vibration has been ordinary with some spasms of increase between May 11 and May 13. Tilt of the ground has shown eastward tendency with stationary spells, the north-south component showing only slight fluctuations.

May 25, 1918.—During the week ending Friday, May 24, 1918, the Halemaumau lava column has continued to rise at the same rate, the central wide floors of recent overflow have swollen up and developed deep crevasses and floods of liquid lava have poured along the wall valleys. A new source of such flooding

is a cone at the base of the west-southwest wall of the pit at the side of the old western well which has repeatedly developed pits and cones in the past. In contrast to the previous week, when the measured rise of the lake was somewhat greater than that of the bench magma, the latter has this week risen more than the lake so as to increase the height of the walls of the inner lake basin.

The surveys yielded the following measurements:

May 17 to 18, central crag rose 8 feet in 1 day to depression 56 feet;

May 18 to 20, central crag sank 1 foot in 2 days to depression 55 feet;

May 20 to 21, central crag rose 1 feet in 1 day to depresion 56 feet;

May 21 to 24, central crag rose 14 feet in 3 days to depression 42 feet.

May 17 to 18, lake rose 7 feet in 1 day to depression 130 feet;

May 18 to 20, lake sank 1 feet in 2 days to depression 129 feet;

May 20 to 21, lake rose 1 foot in 1 day to depression 130 feet;

May 21 to 24, lake rose 12 feet in 3 days to depression 118 feet.

May 17 to 21, crag rose 2 feet per day, lake 1.75 feet per day;

May 21 to 24, crag rose 4.6 feet per day, lake 4 feet per day.

On Saturday, May 18, 1918, about 11 a. m., there was strong overflow from the southwest pond region and from orifices at the edge of the floor west of there, and this flow poured through the south wall valley to the southeast floor along the base of the talus. Rockfalls from the north wall of the pit continued. At 2 p. m. the inner wall around the lake was 15 feet high, there was much fountaining activity in the east arm, smoke rose from many cracks in the northern floors, and the great crevasse extending from the east arm to the north pot had increased in width. This and the swollen surfaces indicated pronounced tumescence. At 1:45 p. m. there was rapid eastward streaming and some appearance of rising lake magma. Lava was splashing inside of glowing pots north and southeast and at 2:30 p. m. the southwest pond was one foot below its rampart and its south grotto was splashing; the rampart had increased in height. At 6:40 p. m. the main lake was depressed about 11 feet within its walls, the southwest pond 3 feet and the southeast pot 5 feet. All the pots and cones were glowing and flaming, including a cone beside the remnant of the north stack and the crevasse extending therefrom to the north pot, where the lava made booming noises. Under the crusted lake gas pressure was high so that there was high spraying from under the crust edges. There were high glowing streaks at the west-southwest edge of the floor as seen from the southeast. Streaming from the central pool was westward to the west grotto where the current bent northward under the bank. The east pool was mostly crusted over, with spells of temporary subsidence and breaking up preceded by violent border spraying. The floor block between the two southeast crevasses was lower. At 10:30 p. m. lava welled up from the edge of the southwest floor and poured in a narrow stream around to the southeast; at 11:10 a second flow much more voluminous followed the same course. At this time fume was thin and there was some rock sliding northwest. The north central wall over the lake was 30 feet high by uplift, while the southern wall of the east pool was only 20 feet high.

On May 20 at 6 p. m. the east pool margin was 10 feet high, that of the southwest pond 2 feet. A flow was pouring across the floor eastward on the southwest side of the southwest pond. The fresh flows of the southern floor were glowing and driblet toes were pushing out from their edges; from the edge of the southwest floor east from the lake jets of lava were flung up with an explosion noise like the exhaust of an engine. Smoke rose densely from the north central and northwestern floors. The floor north of the main lake from the narrows to the base of the west crag was evidently rising to form a scarp twice as high as the southern lake margin. The northeast crag mass also showed a crack parallel to the edge of its escarpment. There was the usual cracking, foundering and recovery of the east pool and the lava pots were flaming.

On Tuesday, May 21, at 5:30 p. m., the lake was lower with walls over 20 feet high, there were six or eight fountaining tunnels and an abandoned shore

Lava lake & NE wall valley, Halemaumau, May, 1918.—*Photo. Jaggar*

Central crag mass and S wall valley, Halemaumau, May, 1918.—*Photo. Jaggar*

rim stood 5 feet above the liquid. The southwest pond still stood at a much higher level and glowing flows lapped the talus west, southwest, south and southeast from a slag heap source against the base of the west-southwest wall of the pit. This was the site of the "griffon" cone of March. The southeast pot had collapsed to an open pit 20 feet across, containing lava 15 feet down streaming westward. The north pot had also enlarged, general crevassing had increased, the northeast talus appeared lower and smoke from many cracks was denser, the southeast floors now smoking like the northwest, but the north crag summit no longer smoked. There was strong hissing towards the west. The ring of new floor had greatly increased in width around and outside of the central, southwestern and western crag masses on the west, southwest and south sides of the bottom of the pit. The remnant of the north stack still stood. A new bridge of crust had formed across the entrance to the west arm and there were fountaining tunnels on the north and northwest sides of the central pool. The southeast region was much crevassed as though it were about to collapse to a pool and was very distinctly swollen up, so that the talus was lifted and tended to form a slumping crack between it and the wall. One small rockfall was seen to the north. Fume from the pit as a whole was greater on this day. A sharp earthquake was felt at 3:30 p. m. At 10 p. m. it was evident that flow from the southwest cone had been renewed and there was vigorous fountaining in the lake. At 11:15 p. m. flowing started again from the west cone, the top of the cone forming a boiling, standing fountain which played in artesian fashion for hours.

On the morning of May 22 there was little change. The inner pit containing the lake was deep, the fume was thinner and the fresh flows still glowed.

On May 23 at 11:30 a. m. a thunder shower with very heavy rain caused cascades to pour over Uwekahuna bluff. At the road terminus near Halemaumau, during a lull when rain was pouring down to the north, the northern part of the Kilauea crater floor showed an even vaporing all over and the heavy beat of rainfall and the rush of water into the cavernous lava made a distinct roar somewhat like wind in a forest.

On making circuit of the pit by south and west the southern inner valley showed greatly increased width of floor, the fresh flows cracking with heat and the upturned slab of old March floor which had formed the lower part of the southwest wall of the pit was now nearly buried. The new floor made a wide platform eastward as well as southward from the southwest pond. The new west cone, between the southwest and west stations was a flat slag-heap some 10 feet high with a sluggish fountain boiling in a pot on its summit, feeding a dribbling cascade with festooned skins ending in a short flow which was extending itself eastward. Farther north the west pond cone was glowing and hissing. The north pot was now a pit containing a lava pond 15 feet below the edge. There was a glowing cone at the northwest pond site. The most conspicuous change observable from the northwest was the pronounced lift of the whole central and southwest region of swollen and cracked floors and tilted crags, and the subordination of the northeast crag mass, now sunken and insignificant. The northeast valley back of it was the lowest depression in the pit. The site of the former north arm emitted bluish fume from hundreds of cracks, and one greater crevasse extended from the north stack through the north pit and across the swollen surface to the east arm of the lake.

The lake margins were 15 to 20 feet high, the crust was cracking and foundering, and the lava in the southeast pit appeared to be connected with the lake through a tunnel at the southeast crevasse. Against the west base of the central crag mass, in the west arm of the lake, the rhythmic fountain was again in action sluggishly breaking at intervals of 30 seconds more or less.

At 4 p. m. the lake was very quiet. At 4:45 a large central fountain burst through the crust of the east arm and a breaking up ensued. At 5:30 p. m. flows broke out from the new west cone and the lake overflowed from its west end. The two flows joined and flooded the southwest pond depression and the flood also poured northward

through the west pond depression. The eastern flow reached the base of the southeast wall of the pit. At 6:30 p. m. a prolonged avalanche fell from the north wall of the pit and smaller ones followed, showing that the upward pressure on the southwest side was depressing the bench magma under the north talus.

On Friday, May 24, 1918, at 11 a. m., the walls of the inner pit were 20 to 30 feet high and the only active spots in the lake were the southeast and west grottoes. A steel-colored, fresh, heavy, crackling flow extended all the way from the southwest cone to the base of the northwest wall of the pot where glowing toes were pushing forward. A heavy stalactite curtain hung before the southeast grotto tunnel. There was a roaring blowing noise from one of the western vents. The lava of the north pit appeared over 20 feet down. The notch made by recent avalanches east of the north station was pronounced and had carried away much of the northwestern end of the northeast fill of 1918 lava. The intumescence of the middle region is so pronounced with its somewhat radial cracking and its lens-like surface, as to afford an almost perfect demonstration of the relationship between weighting by overflow of lake magma and resultant uplift of bench magma. The overflows for weeks have been annular, following the base of the talus and the uplift is consequently central.

The registration of the seismographs of the Whitney Laboratory of Seismology for the week ending at 2 p. m. Friday, May 24, 1918, has been very remarkable in tracing the autographs of at least six strong distant earthquakes as well as one smartly felt local shock and two moderate ones.

The teleseisms were as follows, Honolulu Standard Time: 9:49 a. m., May 19, trace only; 4:26 a. m., May 20, probable distance 3880 kilometers, equal to that of Samoa, Southern California or the Alaskan peninsula; 7:42 a. m., May 20, probable distance 7110 kilometers, equal to that of Chili, where an earthquake is reported; 8:09 p. m., May 21, probable distance 4070 kilometers, equal to that of Samoa or Alaska; 1:50 a. m., May 23, a very powerful shock of doubtful distance, possibly 5900 kilometers, equal to that of the Gulf of Mexico or the Kurile Islands; lastly a doubtful trace 9:22 a. m., May 24.

The local shocks were (1) 3:30 p. m. May 21, felt at the Observatory as a prolonged north-south rocking and generally felt on this island; (2) 7:27 p. m. May 21, (3) 2:30 p. m. May 22. Microseismic motion during the week has been slight, volcanic vibration showed some spasms May 17-18 and thereafter was very slight. The tilting movements were to the east and south, May 17-19, to the west and south May 19-20, to the east and south May 20-22, and to the east and north May 22-24.

June 1, 1918.—During the week ending Friday, May 31, 1918, the lava lake and crags of Halemaumau continued to rise with some gain in the rate of rising of the liquid portion. The observed results are of the same general type as have been recorded recently, but the movements of upward swelling of the hard lava flows have culminated in the creation of new crags and the lakes have increased in size. A very marked movement May 29 to 31 lifted the marginal talus and accentuated the slopes of the crags away from the center of the pit, and at the same time a storm of volcanic tremors was recorded on the seismographs.

The following were the measured changes:

May 24 to 31, 7 days, central crag rose from depression 42 feet to 20 feet;

May 24 to 31, 7 days, lake rose from depression 118 feet to 97 feet.

The rate of rising for six weeks, taking the mean of crag and lake as representing net movement of lava column, was

April 19-26, lake 4.11′, crag 3.71′, mean 3.92′ daily;

April 26-May 3, lake 1.29′, crag 3.71′, mean 2.21′ daily;

May 3-10, lake 1.14′, crag 2.43′, mean 1.78′ daily;

April 10-17, lake 2.86′, crag 3.00′, mean 2.93′ daily;

May 17-24, lake 2.71′, crag 3.14′, mean 2.92′ daily;

May 24-31, lake 3.00′, crag 3.14′, mean 3.07′ daily.

This table is of much interest. It shows that since the strong revival of

rising started there was a maximum at first with lake overflowing the bench magma; then there was a decline in the rate of rising for a fortnight, with rise of bench magma strongly dominant over rise of lake magma; next there was a fortnight of steady rising with the net rate increased 61% and the bench magma still dominant; during the last week the lake has nearly reached the bench magma rate and the net rate has increased 5%. The weekly fluctuation of the lake magma rate was much greater than that of the bench magma and during one fortnight was in the opposite direction (May 10 to 24). The crag movement was more nearly equable than that shown in either of the other columns, suggesting that the bench magma movement perhaps best represents that of the main underground lava column. A single crag does not, however, accurately represent the mean movement of the whole crater floor, which would, if measured at evenly spaced points, gives a still more equable rate.

The average of the weekly means for the composite lava column was 2.8 feet per day for the six weeks. For the lake the average was 2.5, and for the crag 3.1. The crag thus rose 24% faster than the lake and 14% faster than the imagined composite lava column (mean of crag and lake), while the lake rose 14% slower than the latter.

The upshot of this computation is that the swelling up of the pit floor three feet per day since the April rise began has proceeded nearly 25% faster than the rising of the liquid lava, and is now lifting the slide-rock slopes bodily as the circular plug of semi-solid lava pushes upward. The summit of the great central crag is now less than 20 feet below the edge of the pit; its lowest for the period was 152 feet on April 17. Just as the mass sank bodily after the 26th of March, so it is now rising en masse. The accordance with predicted fall after equinox (March 21) and rise before solstice (June 22) has been nearly perfect. A feature of the measurements which throws light on the older records of travellers is that for some weeks past an observer without instruments would have noted **a sinking lake,** for the inner basin walls were growing higher, whereas in reality both lake and margin were lifting, but the latter a quarter faster.

On Saturday, May 25, at 2:30 p. m., the north pit was seen to have increased in size, there was bubble fountaining in the pot farther north and many small lava tricklings were pushing out from the margins of flows under the west station. At 3 p. m. looking from the southwest the west arm and southwest pond were seen to have banks 5 feet high and to show some fountaining activity. A long flow was pouring eastward across the south floor at the base of the wall talus and this was spreading right and left. The east arm exhibited walls 20 feet high and was quiet and crusted over. At 3:20 p. m. the source of the southern flow revived and a fresh overflow from it welled up; this source was the west cone at the edge of the floor under the southwest wall of the pit. The new flow spread to the south a short distance.

On May 26 at 4 p. m. the lake was crusted over and the only fountaining was in the southwest pond. The southeast pit was enlarged, the north pit was more open, the walls over the lake were higher and the north pit crevasse formed an arch as seen from the north with bubbling lava beneath. There was glow also in two openings between the north pits and the central pool, one of them flaming, and another glowing pot was open in the northwest floor. Incandescent flows were sluggishly making toes here and there all over the west and southwest regions. Occasionally the rhythmic fountain would explode in the west arm. The southwest pond was continually fountaining against its northern bank and streaming in it was westward from a tunnel arch at its east end. At 5 p. m. temporary subsidence broke up the crust on the main lake, rock slides were numerous towards the northwest and at 6:10 p. m. a heavy fall into the lake from the southeast crevasse took place and started violent fountaining. Smaller falls into the southeast pool indicated that the broken bench matter between the two pools was crumbling down. This was the result of a warping upward of the bench magma which tended to make a tumble of the blocks between the crevasses. A strong slide

of rocks from the northeast crag mass into the northeast valley showed that that mass was tilting farther northeastward. A similar fall from the wall of the central crag mass into the southwest pond showed that that block was also being pushed up in the center and increasing its southward slope. Glistening splash marks on the shores of the lake indicated that recent rock tumbles had been numerous. On the northeast wall of the southeast pit there was a glowing and flaming spot high above the liquid level. Small rock slides from the walls of Halemaumau occasionally took place. On the evening of May 27 large falls of rock into the southeast pool were reported.

On Tuesday, May 28, at 3 p. m., there was a fresh flood of lava in motion on the south floor, the southwest pond was overflowing and splashing against its south bank and the west cone was an additional source of flows. The whole central region appeared more uplifted, the crevasses were wider, the east and southeast pools had greatly increased in size by a falling away of the banks and the cracked isthmus separating them was much narrower. The whole southeast floor was tilted southward making the south rim of the southeast pit comparatively low. Similarly the whole northeast floor was tilted northeastward so that the east bank of the main lake was much lower than the cliff over the central region. A new escarpment rose above the north pit depression on its north side extending thence to the north side of the northwest pond depression. A new north lake was forming from a union of the two pits, the southern shore of the new lake rose by gradual slope to a second escarpment on the north side of the central pool. The recent floods west and south were apparently being compensated by upward push east and north. The enlargement of the east pool depression was in the directions of he north and southeast crevasses. The south wall valley appeared much sunken.

On Wednesday, May 29, at 5 p. m., the upward swelling continued so that the inner cliff was fully 40 feet high above the central pool, the south side of the east pool and the north side of the southeast pool. At the south side of this pool and at the east end of the lake the bluff was only 20 feet high. The pools were sluggish, showing four or five spraying fountains which would break explosively from under the crust near the margins. There were traces of a new inner spatter bench. Rocks were sliding at the southeast crevasse. Glowing flows south, southwest, west and northwest moved slowly and made crackling noises.

Looking from the north and northwest the most striking change was the irregular breaking up of the whole floor into new crags which were slowly rising and tilting. The north chasm arch had collapsed, separating the northern pond from a smaller pot north of it, the latter adjacent to the north stack remnant. A squarish block of the floor was tending to lift and tilt northward on the west side of this pot so as to create a new northwest crag. In similar fashion the floor block containing the southeast pit had risen on the side of the east pool and sunk southward, tending to form a new southeast crag. The southwest pond was high, level with its rampart and bombarding its south bank. Much smoke rose from the northern cracks. At the base of the talus north and northwest the wall valley appeared low as though that should be the next place to fill.

On May 30 at 2:30 p. m. the west side was smoky, one fountain boiled in the north pot and the main lake was quiet and crusted over. The southeast pond was enlarged and showed surface streaming westward to a grotto under the bank with steady fountaining at the entrance. At 3:10 p. m. the east pool broke up and subsided three feet but immediately crusted over and became quiet. The southwest pond at 3:20 p. m. was flush with its margins and stagnant.

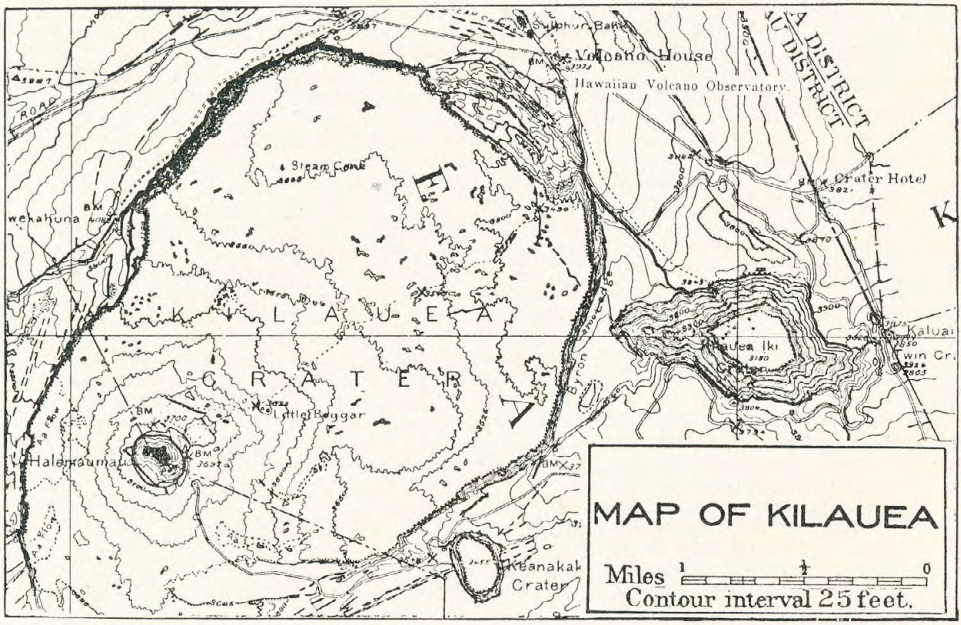
On Friday, May 31, 1918, at 1 p. m., it was evident that the rising bench magma was in extraordinarily rapid motion, for small slider took place almost incessantly at the southeast crevasse, and along the top of the eastern and northeastern talus. A deep gully was forming between the top of the talus and the wall on this side in contrast to that on other sides. The floor ring south and west was greatly wid-

ened. The lake walls were 30 feet high with fresh spatter rims 10 feet above the liquid. The southwest pond, however, was only 3 feet below its rampart. The lakes were crusted over, the crusts cracking and foundering from time to time, each break-up being inaugurated by explosive blowing. The tumescence of the central region was producing marked centrifugal tilt. Thus the central crag and the entire southeast, south and southwest floor area were tilting southward so that the northern scarp of the central crag had replaced the southwestern one as its summit. Similarly the west crag was tilting westward, the new northwest crag northward and the northeast floor and crag mass eastward. The pit was quite clear on the east side but smoky towards the west. The northern pond was increasing in size.

The seismographs of the Whitney Laboratory for the week ending at 2 p. m. on Friday, May 31, 1918, registered a distant strong earthquake at 9:27 a. m. May 25. The distance indicated was approximately 3600 kilometers, probably a rift movement under the ocean. Four small local shocks were registered respectively 9:49 p. m. May 25, 4:16 a. m. May 26, 7:19 p. m. May 26 and 4:42 a. m. May 28. Microseismic movement has been moderate with slight increase. Volcanic vibration increased from moderate values beginning May 28 to stormy spells which May 30-31 became excessive. Fifteen or twenty spasms occurred each hour of the day and the number of spasms was notably greater during the hours of stronger north and east tilt. This vibration period was coincident with intense tumescence of bench magma and the lift of wall talus in the pit, but not with strong fountaining or overflowing. The daily tilting movement has tended eastward and northward, this tilting increasing strongly May 30.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. All scientific exchanges should be sent to this address.

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, JUNE, 1918 No. 6

VOLCANO OBSERVATORY, June 15, 1918.—During the fortnight beginning June 1, 1918, mild subsidence has followed the previous long rising spell which culminated on June 4. On that date the summit of the central crag was depressed only 6 feet below the east rim of Halemaumau and the lake at the central cove stood 87 feet below the rim. The crag was plainly visible from Volcano House. The next day, however, it sank out of sight again and on June 15 its summit was 18 feet below the rim, while the lake had gone down still farther to a depth of 107 feet. This subsidence before the solstice is quite in accordance with the expected curve of rise and fall.

The central crag had thus sunk 12 feet in eleven days, a rate of 1.1 feet per day. The lake sank 20 feet in eleven days, a rate of 1.8 feet per day.

On Saturday, June 1, 1918, at 2 p. m., a new position of flow from the wall crack had been inaugurated under the northwest station where a powerful stream of liquid lava was welling out of the top of the talus and pouring over the rock slope to make a new fill in the depressed northern wall valley. A cone at the source was puffing loudly. The northern pond was now greatly enlarged with dimensions approximately 100 by 75 feet and two large fountains in it threw lava spray to considerable heights. At 2:30 p. m. inspection from the northeast showed that there had been much caving of the central crag and a large grotto had formed under its northern cliff. The southeast bench stood 25 feet above the east arm of the lake and there were frequent falls of rock from it. The east channel and the southeast pond were very quiet and crusted over. The southwest pond was flush with its rim on the south side.

On June 2 at 4:30 p. m. there was increased activity and swift streaming southeastward with traveling fountains. From the north at 5 p. m. the northwest wall cone was seen to be still pouring forth a flow and there was much activity in the north pond while the northern region in general was smoky. At 6 p. m. a succession of falls of rock from the raised bench on the northeast side of the east arm took place and the whole block there settled about five feet. From the east and southeast rim of the pit numerous small flows could be seen in motion in the south and west wall-valleys, those of the latter flowing northward. At 6:40 p. m. a somewhat prolonged slide was heard toward the northwest and there were some rolling rocks which plunged down the back of the northeast crag slope.

In general the scene at 7 p. m. indicated a marked change culminating the recent movement. The crags were higher though the lakes appeared relatively low and showed cavern arches at the central cove, at the cove on the north side of the east pool, and strong overhang of the inner spatter bench in the southeast pool. This bench was pronounced in both these pools some 8 feet above the liquid. A bright trickling stream of lava poured from the northwest wall cone. There were brilliantly glowing and flaming cracks in the upraised ledge next to the northwest pond on its north side and fresh glowing driblet flows covered the northwest floor. The new northwest pond was an isolated pool separated by crust from the large north lake which lay deeply sunken amid surrounding crags. A circular pit had formed between the north and the main central lakes and a deep crevasse lay between this pit and the old west crag. From a long slit in the summit of the west pond cone a blue flame was playing with hissing noise,

WEEKLY BULLETIN
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Hawaiian Volcano Observatory

Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii. under the Act of August 24, 1912.

and another blowing cone had formed at the southeast base of the central crag mass. The southwest pond showed an eight-foot margin. The lake activity of streaming, fountaining and wide glow rims gave the impression of subsidence, but this may have been mostly uplift of the bench magma, for the glowing trickle flows and blowing cones indicated pronounced gas pressure.

On Monday, June 3, at 11:30 a, m.. measurement showed continued rising, the lakes appeared somewhat higher, the southern driblet flows were still in motion and the southeast cone was seen to be a small stack four feet high continuously hissing. This cone stood at the end of a vertical crack extending from the east pool along the west side of the southeast pond. There were occasional cracking and foundering of crusts in the lake and very large fountains would form in the southwest pond and in the north and east corners of the east pool. The eastern talus was still uplifting and in motion. The new northwest spatter heap was hissing and fresh lumps ejected from it had fallen on the high rim of the pit northwest while the cliff face below was plastered for half its height with the spatter from explosions of the cone. Moving trickle flows poured from the wall crack west-northwest and there were similar places all along the base of the western and southwestern walls of the pit. The west pond cone was blowing and glowing. The east side of the platform of the west crag mass was tilted up into an escarpment. The former southwest crag and also the southwest wall slab were by now entirely buried under fresh flows. The west pool of the main lake had become cut off as a small oval pond. The former south pressure ridge was nearly buried under new flows.

Tuesday, June 4, 1918, marked the culmination of rising. The back slope of the northeast crag mass was inclined fully 45° in places, while the recently uptilted floor on the northeast side of the north lake was inclined 22° to the northeast and the southern platform of the west crag mass 25° to the west. These figures give some notion of the high centrifugal tilt due to tumescence. The slope of the lava heap against the northwest wall was also about 25°.

At noon on this day the bench magma was rising strongly as shown by small rock slips south, east and northeast, many of these into the wall crack between talus and cliff. The floor crevasses southeast and north had become enormously wide. The lakes appeared low but the cavern arch on the north side of the east pool was submerged. The southwest pond, some three feet beneath its rim, sank three feet more at 12:30 p. m. and this subsidence extended to the main lake also where there was turbulent fountaining east, northeast and at the central cove accompanied by eastward streaming and formation of thin skins. A cavern under the northwest side of the southeast pond appeared as though extended in the direction of the central cove. At 12:15 p. m. there had been a strong flow from the west pond cone which welled out and spread beween the edge of the newer western flows and the slope of the west crag mass. While this flow bubbled up the lakes subsided. The northwest wall heap hissed continuously and appeared higher.

There was now a heavy filling of driblet flows in a belt 50 to 100 feet wide which extended westward and southward from under the north station. This fill had been fed from the wall crack in many places and it appeared to have weighted down the western half of the pit floor, while the eastern half was lifted. The upward swelling and cracking of bench magma appeared to center at the pools, so that there was a distinct sag between the bench slopes which radiated respectively from the northern and central pools.

Large cracks cut through the north crag. The northeast valley was now much below lake level. A glowing cavern led southward from the north lake.

In the evening the main lake was heavily crusted and higher, moving flows were seen on the southwest floor, there was glow at the base of the southeast cone and two falls from the west bridge into the lake appeared to rest on a shoal without sinking.

On June 5 at 3 p. m. the main lake was quiet and crusted over, with sinking spells about every ten minutes which revealed a glow edge around the lake a foot deep. Smoke was thick to the north, the pools there were inactive, and the northwest cone was puffing. The crag summit had subsided so as to disappear from the view of the distant observatory. The inner walls over the lake were 40 feet high, and had fallen away at the promontory north of the central channel. The southwestern and northern coves of the east pool had increased by collapse of walls. The southwest pond showed 5-foot ramparts. Flows were in sluggish motion on the south floor and at the southeastern vents. No rocks slid on the east talus but one tumble fell into the southeast crevasses about 5 p. m. The turning point from rising to sinking had been reached.

On Thursday, June 6, about 6 p. m., an important change to subsidence of the main lake was shown by a cascade into the lake from the west. An arch 10 feet high had broken away from under the west bridge, and through this from the west arm pool a cascade poured over a bench three feet higher than the level of the lake. This cascade diminished in height at 6:30 p. m. as though the lake had risen, and such fluctuations recurred, but the inrush was continuous, and there was inflow also from the north side of the bridge.

Other evidence of relative subsidence of the lake was furnished by a large noisy fountaining cavern opened on the north side of the east pool. Later this became quiet and a large central fountain developed in the east pool and played continuously for over an hour, engulfing crusts from east and west. Streaming in the southeast pond was slow into the large southwest grotto which glowed brilliantly. High fountain fling was seen at the southwest pond. A steady green flame burned at the southeast floor-cone without noise. A glowing cone stood high above the lake at the southwest cove of the east pool. The spatter ramparts fell into the lake from time to time and at 6:45 p. m. a large cone north of the west bridge fell into the lake in two pieces, leaving a glowing wall still incandescent a half-hour later.

On June 7, 1918, at 2:30 p. m., there was rumbling and smoke at the northern ponds but no visible fire. At 3 p. m. seen from the southeast the only activity in the main lake was at the southeast grotto, and smoke was abundant. At 3:20 p. m. the east pool broke up and this spread over the main lake, six fountains played on the margins and a central fountain broke into activity every ten or fifteen minutes.

At 3 p. m. on Saturday, June 8, the east pool again showed one central fountain tending to continuous action for a half-hour or more, and strong boiling at the southeast grotto. At 3:35 p. m. a collapse of the bench on the northeast side broke up the crust, started general effervescence, and revealed rapid streaming towards the southeast. At 4:25 p. m. a large fall of the bench on the northwest margin of the southeast pond made commotion there, followed shortly afterward by collapse at the southeast grotto of the east pool. The "perpetual" fountain and the many collapses gave evidence that a period of moderate subsidence was in progress.

June 9 at 4:30 p. m. conditions were unchanged, there was much activity in the pit of the southeast pond and the crumbling of the partition betweeen this pit and the east pool was marked by frequent falls of rock. Every fifteen or twenty minutes the large fountain in the east pool would break into furious activity. Border overflowing from the wall crack was renewed on this day. At 6 p. m. a flow eastward was pouring from the northwest cone under the wall, and flows were trickling on the southwest floor.

Monday, June 10, there was evidence of rising, or at least of arrested subsidence. A new inner shelf around the main lake stood five feet above it, and

the lake was crusted over. At 3 p. m. there was no fountaining, there was hissing northwest, and smoke was thick. The southeast pit was dark and smoky, but rumbling.

June 11, at 3 p. m., there was little change, the inner shelf was 5 feet high, everything was crusted over and smoky. The dome over the southeast grotto collapsed, leaving a sheer wall and a few minutes later there was a rock fall into the southeast pit.

June 12 at 3 p. m. inspection from the north showed the north pools to be crusted and the northwest wall cone emitted blue fumes quietly. From the southeast the southeast pit was seen to contain a new inner bench marking a recent strong rise, and a fall of rock from the walls was seen.

On Thursday, June 13, 1918, at 7 p. m., the lakes were crusted over and very sluggish, with one or two border fountains. Breaking up took place, first in the main lake with eastward streaming, then in the southeast pit with westward streaming and a fountain on the south side; finally the southwest pond became active with a fountain on its east margin. The southwest pond stood slightly higher than the main lake. There were glowing spots in the southwest and west floors and a banner of flame played above the west side of the west bridge. Smoke was moderate, no rocks fell, and everything appeared stagnant and stationary.

The pit during these days was extraordinarily dark at night as seen from a distance. This seems to be the expected interval of subsidence and stagnation prior to the solstice, in accordance with the past habit of the lava column.

On June 14 at 6 p. m. there was little change. Both lake and southeast pond showed inner shelves five feet high, the cone on the southeast floor was smoking, a flaring pale greenish-yellow flame played above a 2-foot chimney some six feet above the lake level at the central cove (southwest side east pool). The northwest wall-cone and the west pond cone on the floor were both glowing. There were occasional blowing and spraying border fountains on the north side of the central channel and at the southeast grotto. Whitish stain appeared on the west side of the northeast crag mass.

There were now nine crusted ponds in the pit as a whole, occupying five pit depressions, one, however, being an open flat surrounded by a cone (the west pond). The north and northwest pools occupied the north pit; the north central pit lay between these and the main lake; the latter occupied an elongate large depression, with the central and east pools constituting the largest lake, while the west-arm pond and west pot were openings in the crust filling of the western part of the depression. The southeast and southwest ponds occupied small pits of their own.

Only three of the older crag masses persisted, namely the central, west and northeast. New crags in process of formation, uplifted floors, lay north and south of the north pit, and south of the east pool. A horse-shoe of flow heapings made a floor around the outside of the craggy uplifts, widest on the southwest, and extending eastward and northward for a third of the circumference in each direction.

A very pronounced earthquake, making long slow swayings, was generally felt on Hawaii at 11:13 a. m. June 14, 1918. Its record on the seismographs continued for three-quarters of an hour. The pens, which had been flung off, were immediately replaced on the drums. The long duration would suggest a near shock of great intensity. The amplitude of the first movement of the ground was sharply marked to the east and south, and eight times greater east than south, implying a horizontal thrust S. 80 E., or directly away from Mokuaweoweo, the summit crater of Mauna Loa. At Naalehu in the southern part of the island the shock was sufficiently powerful to throw things off shelves in a westerly direction (the ground beneath being displaced to the east).

VOLCANO OBSERVATORY, June 22, 1918.—During the week ending Friday, June 21, 1918, steady but almost imperceptible subsidence of the Halemaumau lava column has continued, both lake and central crag sinking 13 feet in the six days from June 15 to June 21, an average movement of 2.17

feet per day. On June 15 the central crag was 18 feet below the rim of the pit and the lake at the central cove 107 feet. On June 21 the depression of the crag was 31 feet and of the lake 120 feet.

The conspicuous features on Saturday, June 15, 1918, were the high heap of lava above the wall crack along the base of the south and west walls of the pit, making a floor sloping inward: the great height of the uplifted central floors which now cut off the views of the lake from the north and nearly obscured the view of the southwest pond from the east: and lastly the lifted marginal talus, so that it was now a ridge in many places separated from the wall by a gully. Activity was slight and smoke moderate. There was some hissing from the northern ponds and streaming in the southeast pond was towards the northwest.

On June 16 at 4 p. m. the lake was still quiet but a half hour later there was a breaking up of crust with some fountaining and eastward streaming. At 5 p. m. there was fountaining in the north lake and loud hissing from the northwest cone.

On June 18 at 4 p. m. both measurement and observation showed slow continuous subsidence. The inner cliffs appeared somewhat higher, gas puffing had ceased, the volume of smoke was moderate and the lakes were mostly crusted over. The floors of recent overflow were heavily crusted and cracked. In the main lake there was evidence of very slow streaming to the southeast shown by a zone of festooned skin extending from the central region in a curve which ended at a place of fountaining bombardment against the south bank of the east pool. At the place formerly called the west bridge, which separated the central pool from the west arm, there was now a wide beach of hard lava sloping eastward and this greatly diminished the size of that pool. There was a similar wide inner floor on the north side of the east pool. Possibly these were in part emerged flats of lake bottom. The southwest pond stood low within its pit so that a glowing cavern was revealed at its west end. No activity was discernable in the northern pools.

A visit on this day to the lava tube leading westward from the collapsed northeast fill discovered typical worm-shaped stalactites of the cavern variety up to twelve inches long, and wholly in 1918 lava which was red hot in April. It is even now so hot that the deeper portions of the tube are intolerable and specimens could not be collected with unprotected hands. There was no trace of water drip. This occurrence proves finally that such stalactites are formed by remelting in chambers freshly vacated by liquid lava and heated by hot gas. Where the cone of glassy lava had been, which it will be remembered was formed during a heavy rainstorm on March 13 last, the site now being a tumble of broken rocks, there was revealed a light porous lava lining the cavities below, greatly oxidized to a yellow ochre color, suggesting that the iron of the rock had been transformed to the hydrous oxide.

At 7 a. m. on Wednesday, June 19, the lake appeared still lower and some fresh tumbled rocks from the walls on the edge of the south floor showed that there had been mass subsidence of the lava column. Streaming was eastward in the east pool with a large central perpetual fountain in action there, and there was some fountaining in the southeast pit. Smoke was moderate and no activity was visible in the northern pools. The eastern talus ridge had somewhat subsided and there was a deep gully next to it on the wall side.

On June 20 at 7 a. m. fountaining was again seen in the center of the east pool with streaming surface currents pouring towards it from both east and west, and the effervescence occasionally took the form of lines of traveling fountains which migrated to bombard the south bank. A flaming chimney had formed above the bank of the lake on the south side of the central channel. Occasional strong hissing broke out at the southeast margin of the southeast pond, where fountaining also was seen. A smoke hole was developing high up the east talus. At 4 p. m. the lake was quiet for fountaining at the southeast bank. About 6 p. m. there was a breaking up with rapid eastward streaming. There was some fountaining in the northern ponds but the smoke rising from that region was dense.

On Friday, June 21, 1918, at noon it was evident that in general the lava column continued to subside very slowly, there was much smoke and changes were few. The southeast bench now appeared higher than the north region, as the latter was subsiding around the north lake. There were marked tunnels at the west end of the southwest pond and on the north side of the east pool. Small slides of debris took place from the northeast wall of the pit. The cliffs around the main lake showed much spatter. In the central channel there was turbulent bubble fountaining with streaming from both east and west. The inner bench around the southeast pond showed overhang with stalactites. In addition to the chimney south of the channel there was another glowing orifice some ten feet above the lake on the south side of the east pool. The north pools showed a smooth crusted surface, the main open pond being there at the east end. The northwest floor was seen to be made up of recent flows piled high against the base of the wall and sloping inward just as in the case of the fresh flows to the southwest.

A visit to the south cone on the edge of the pit showed that its summit had completely collapsed, and the interior cavernous shell was intolerably hot and coated with deposits of alum stained with sulphur. There were extensive stalactite accumulations on the northern interior of the broken dome with glossy reddish surfaces.

The following is the report of seismographic registration in the Whitney Laboratory for the three weeks, May 31 to 2 p. m. Friday, June 21, 1918.

For the week ending June 7 two strong distant earthquakes were registered, respectively June 2, 2:51 a. m., and June 4, 6:50 a. m. The phases of the first appeared to indicate a distance approximately 5000 kilometers, equal to that of Behring Straits or Fiji; the second 3650 kilometers, an origin probably under the ocean. Four local shocks occurred as follows: 2:13 p. m. May 31, 3:30 p. m. June 1, 12:49 a. m. June 6, and 12:48 p. m. June 6. Volcanic vibration was strong in the early part of the week, decreasing thereafter. Microseisms increased towards the end of the week. Tilting somewhat increased to the east and south until June 3, with recovery in the opposite direction thereafter.

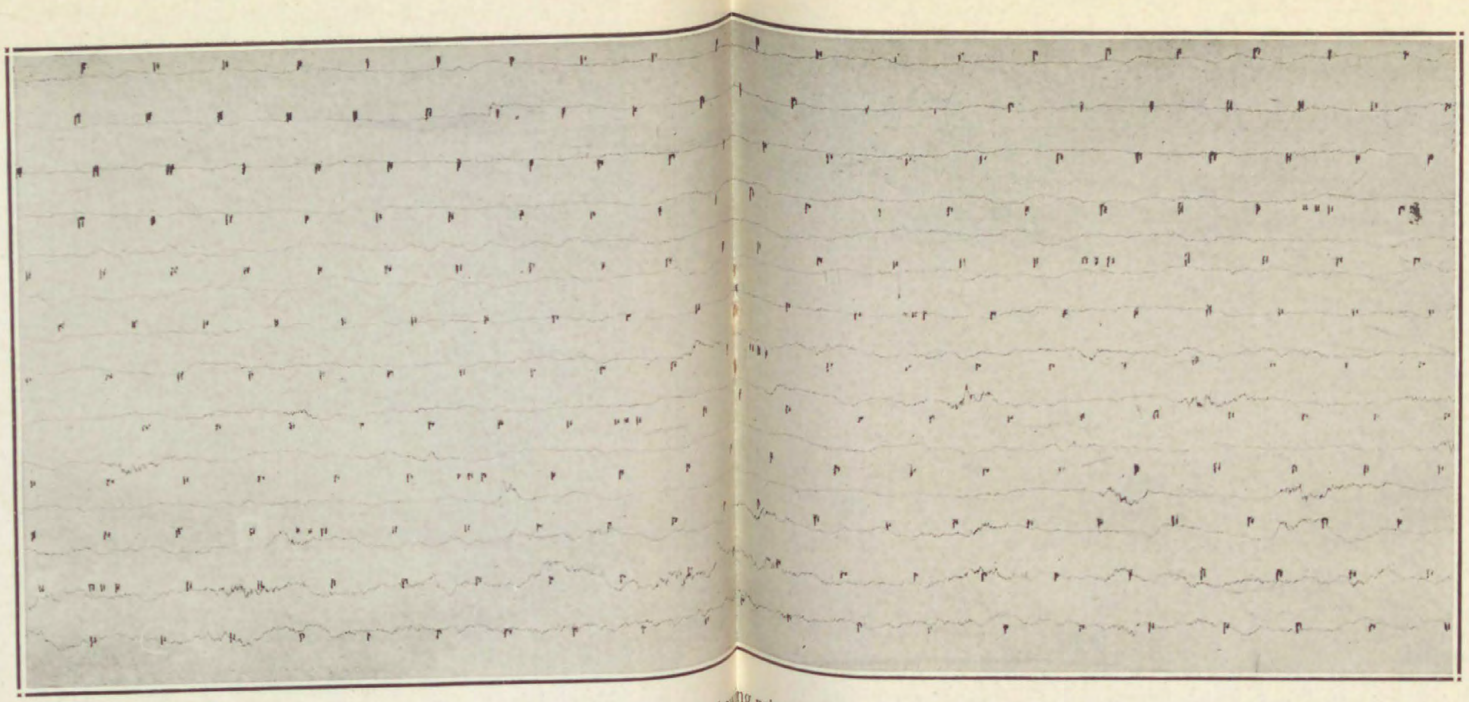
During the week ending June 14 one strong distant earthquake was registered at 6:09 p. m. June 11; the distance of origin was not determinable. Local shocks occurred as follows: 2:37 a. m. June 8 (very small); 4:03 a. m. June 12 (small); 11:13 a. m. June 14, a very prolonged felt shock, which first threw the pens off the drums. After about a minute these were replaced and the movement of the ground continued for three-quarters of an hour in long slow pulsations which resembled the long waves of a distant earthquake. Volcanic vibration was slight until June 10 when very strong spasms occurred which diminished during the next three days. Microseismic motion was moderate. Tilting increased very strongly to the north until June 11 and thereafter the records indicated a stationary condition.

During the past week ending June 21 one teleseism, the long waves only, was registered at 6:04 p. m. June 20. Local earthquakes were registered at 2:54 a. m. and 3:29 p. m. June 15; 6:28 a. m. June 19 (felt). Volcanic tremor has been moderate, with some spasms June 16 to 18. Microseismic motion was moderate and decreasing. Movement of tilting has shown little change except for slight tendency west and south towards the end of the week.

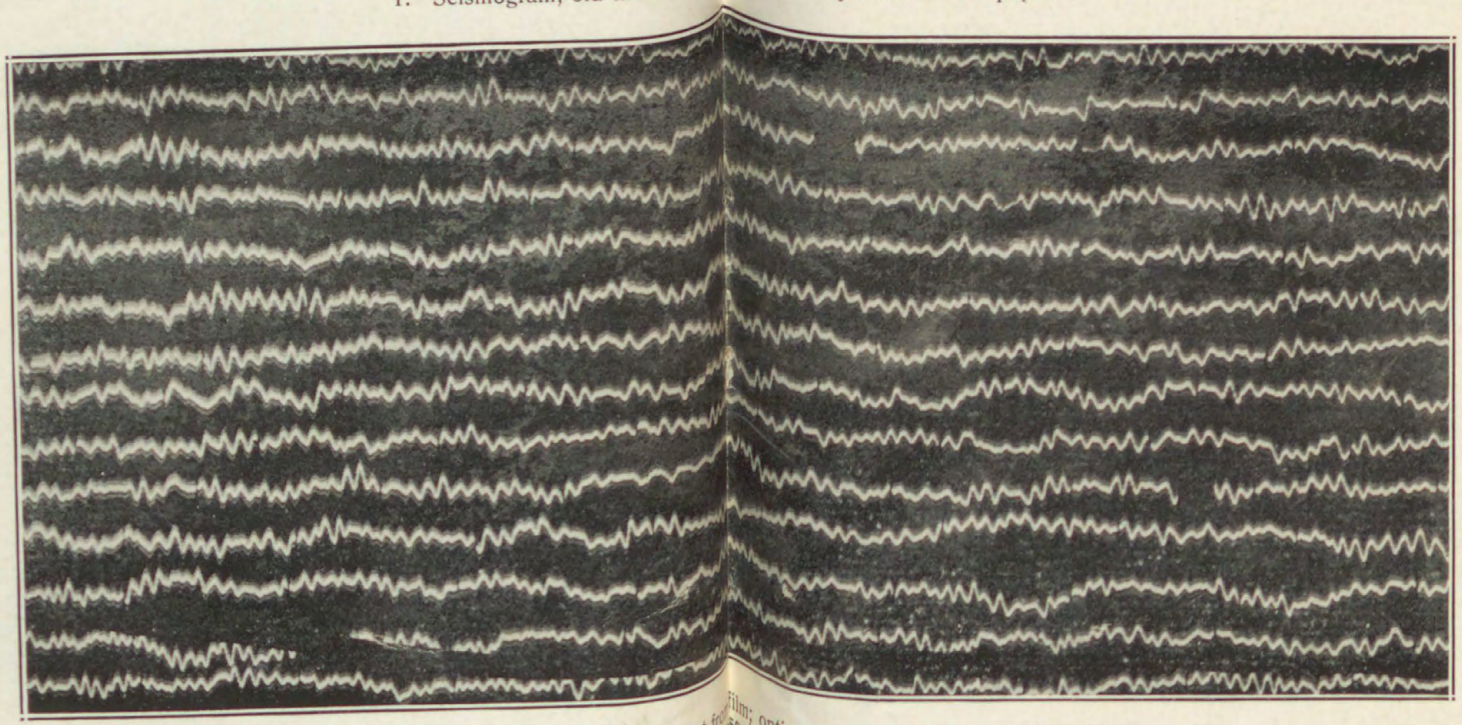
Dr. Arnold Romberg, professor of physics, College of Hawaii, has accepted the position of assistant in physics at the Observatory for the summer months.

The north crater hut at Halemaumau, which has been a landmark near the pit since 1912, and was part of the original hut erected by Mr. Perret for crater experiments in 1911, was removed on June 21 and will be set up in the Observatory grounds.

VOLCANO OBSERVATORY, June 29, 1918.—During the week ending Friday, June 28, 1918, the lava column of Halemaumau responded to the solstice by ceasing subsidence and rising slightly until June 26. This was followed by depression the next day and slow rising thereafter, the central crag at the end



1. Seismogram, old method, showing print directly from smoked paper.



2. Seismogram, new method, showing print from film; optical registration, same pendulum as above.
For explanation of illustration see note at end of report. Ed.

of the week being about 31 feet, and the lake about 125 feet below the rim of the pit. In general, the week following solstice (June 22) appears to mark arrested subsidence and a stationary condition with rising symptoms.

On Saturday, June 22, 1918, at 6 p. m., the main lake was quiet, with a fan-shaped area of glowing and streaming melt which converged to a fountain on the south bank of the east pool. Both the main and southeast pools appeared higher with reference to the inner spatter ledge. There was some hissing and spurting from under crusts. Glowing apertures had reappeared at the base of the southeast cone on the lifted floor. There was active fountaining from time to time at the east end of the north lake. Glow over the pit as a whole at night was brighter.

On June 23 at 4 p. m. the lakes were quiet and crusted, one fountain was playing on the south side of the east pool. Measurement revealed stationary condition of both lake and crags since June 21. At 5:15 p. m. a fall from the southeast ledge into the lake, followed ten minutes later by collapse of the bank north of the central narrows, indicated movement in the column, and the lake subsidized a foot or so with break-up of crusts and eastward streaming. Strong fountaining bombarded the south bank. Prior to this the crusted lake had stood one foot below the inner shelf and there were bubbling currents rushing to the bank at the southeast corner. There was continuous hissing at the cavern under the south edge of the southeast pond. The glowing edge of the north pool extended farther west than on the previous day. The flaming hole at the base of the southeast cone was conspicuous seen from the south.

The northwest cone against the wall and the west pond cone were fuming, and the latter showed a deep glowing and flaming rift on its west side. On the side of the northwest pond headed towards the west pond cone, where the former chasm and tunnel lay, there was a glowing cavern with lava pounding within. Occasionally outbursts of fountaining activity broke out at the east end of the north lake. The platform southeast of the old west crag was now a steep escarpment, itself a marked craggy eminence. In the northwest floor made of recent flows there was a collapsed oval area. Fresh fallen rocks from the wall lay on the southwest floor, and formed fresh avalanche talus. High above the southwest pond on the ledge above it south a chimney glowed and flamed. The streaming of this pond was eastward into the cavern under the chasm which bounds the cliff wall of the central crag mass on its south side. The pot of the former rhythmic fountain had become an oval pond glowing quietly. General conditions on this day showed renewed gas burning and higher temperatures, without much pressure.

On the evening of June 24 high pressure was renewed with every sign of rising lava. Ten or more fountains of the spraying and constructing type were building up the banks of the lake, glow and flames showed at the cones and gases could be heard hissing forth from confining orifices. The fumes were thinner.

This was confirmed by survey the next morning Tuesday, June 25, 1918, at 9 a. m., when the central crag was found to have risen two feet and the lake bench was built up a similar amount. The gas pressure had slackened and was now that of moderate rising, with five fountains on the edge of the main lake, a hissing fountain in the southeast pond, and hissing noise from the northwest pond and possibly from the west pond cone. Smoke had greatly diminished and small movements in the talus evidenced motion. The cavern at the west end of the southwest pond had collapsed to a channel leading toward the west arm pond. At 8:50 a. m. there was a temporary sinking spell accompanied by violent bombardment of the south bank of the east pool. Everywhere the streaming was toward the border fountains which built up the spatter hanks. In the depression north of the northern lake there appeared to lie a crusted round pond.

On June 26 at 9 a. m. the levels were unchanged and at 10 a. m. the lake appeared rising. Occasional small rock slips occurred. Five or six fountains pounded on the banks of the main lake, one of these building a crescent of spatter on the south side of the east pool. Clear seeing revealed the fact that the plateau between the north and

central pools had been breaking down so as to extend the north lake depression southward as though restoring the old north arm. Ocasional breakings up of crust revealed eastward streaming. The bench magma appeared to be rising most toward the east(or sinking toward the center) for it was only one foot high around the central pool, but three feet high at the east end.

The angular measurements of Thursday, June 27, made at 4 p. m., showed that both lake and central crag were slightly lower, and the crag had settled more than the lake so as to give the latter the appearance of being higher. A new spatter bench had been constructed, there was fresh festooned overflow on the inner shelf north of the central channel, a glowing chimney showed a round hole about 8 feet above the lake at the south side of the east pool and a crescent cone was in process of building on the north side. There were occasional continuous central fountains and four or five fountains played against the bank. Fuming had increased. A new crack extended from under the south station towards the southwest pond across the recent flows of the southern floor. At 6 p. m. there was fountaining in the north lake and the west pond cone was blowing noisily and occasionally ejecting spray. The next day, June 28, conditions appeared about the same with less fume and subsidence arrested.

OUR ILLUSTRATIONS.

SPECIAL NOTE—

During the recent period of moderate activity and stationary lava little work has been done at the crater, but the staff of the Observatory has been very busily engaged in instrumental problems. The Director has recently compiled the statistics of the tiltings, trembiings and quakes registered for the past five years, with the object of opening to view the seismometric problem as it directly concerns the lava column and the volcano centers of activity. Dr. Romberg comes to the Observatory in order to subject this problem to the test of experiment and is now at work with a heavy horizontal pendulum, making modifications designed especially to meet the local needs. There is, of course, no interruption to the regular routine registration with a pair of the older type instruments. The local quick-period earthquakes, the volcanic microtremor, and the extraordinary tiltings or changes of the plumb-line, are the three distinctively Hawaiian phenomena.

Pendulums recording on smoked paper lose many of the details of ground motion because of excess of friction in the apparatus; they are further inaccurate because of lack of damping designed to keep them from oscillating mechanically; and the registering clockwork mechanisms are defective in that the smoked paper moves too slowly to show plainly the important initial motion of earthquakes and the very quick motion of local ones. All the mechanical imperfections combine to yield only mediocre results, and the standard instruments, designed for cheapness and convenience of operation, are ill adapted to such special problems.

The accompanying figures show prints directly from two seismograms made before and after improvement, with the heavy pendulum and its chronographic revolving drum. They are exhibited to show the first results of improved photographic registration contrasted with the old method.

This older procedure involved an undamped pendulum, numerous pivots, a magnifying lever and needle scratching the record on smoked paper which moved only about 13 mm. per minute; the minute marks were stamped on the same paper by a separate mechanism, and this made it necessary to know and allow for the distance of minute-marker from pen in order to assign its exact time to any earthquake disturbance of the written line. This machine lost many of the distant earthquakes entirely, registered the tremors very irregularly and because of instrumental friction the needle failed to return to the safe straight line where deflected out of it. Both tilting and local earthquakes produced such deflection.

The instrument was rebuilt by Dr. Romberg with materials at hand, in consultation with the writer, so as to make its record with a ray of light from a small electric bulb. All pivots but

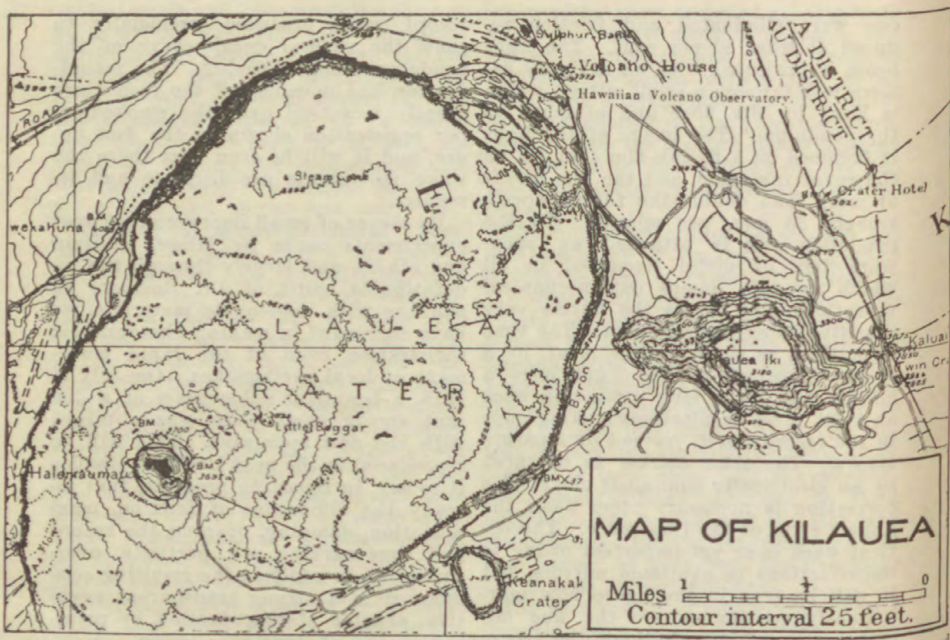
one were eliminated and friction reduced at least 80 per cent. The light beam is projected with an ordinary camera lens through a small mirror, which is hung by silk fibre and attached to the pendulum. The image of the light is focussed on a Kodak film clamped on the revolving drum, and the film moves at more than double the former speed, namely 33 mm. per minute. To the pendulum arm is attached an open-work box of metal immersed in oil which strongly damps out mechanical vibrations, but leaves the mirror very sensitive to earth movement. The time is marked, as shown in the print, by a short extinction of the light once a minute and by a long extinction once an hour, these occultations making gaps in the record itself, instead of separate marks. The time marker is operated by an electrically connected clock. No correction is necessary other than the known error of the time-piece. The optical work is as yet imperfect owing to imperfections in available mirrors, but it will be seen in the figure how marvellously continuous are the fine microtremors and how rhythmic the grouping of the slower microseisms, the whole series showing longer slow wave movements which deserve investigation. The strong zigzags at the beginning of the record were produced artificially to show the natural decay curve of the pendulum when disturbed. The magnification and openness of the record are greatly increased over the smoked-paper registration shown in the first figure, and it will be seen that there the wave movements are illegible and irregular.

By means of small improvements over experiments made by Milne, Galitzin and others, and largely through the indefatigable spirit of Dr. Romberg in working with inadequate materials, we have succeeded in making photographic registration even of the rapid movement of local earthquakes. On July 2, 1918, a beautiful seismogram of a distant strong earthquake was obtained with the new apparatus. This will be reproduced in the next Bulletin. Suffice it to say, in reporting progress, that already the difficulties of friction, magnification, damping, opening the record and time-marking are partially overcome, and in addition the resulting seismogram is a strong transparent negative, capable of reproduction by printing on any photographic paper.

Very respectfully,

T. A. JAGGAR, JR.,

Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Boschi-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

		Expressed by accelerations measured in millimeters per second per second.	
I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a_0 or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, JULY, 1918 No. 7

HAWAIIAN VOLCANO OBSERVATORY, July 6, 1918.—During the week ending Friday, July 5, 1918, the lava column has fluctuated but slightly with a tendency to uplift of the northern part of the floor of the pit, including the north crag. The following measurements during the last fortnight show how stationary the lava has been:

June 21, depression of lake 129 feet, depression of central crag 31 feet.

June 23, depression of lake 130 feet, depression of central crag 30 feet.

June 25, depression of lake 130 feet, depression of central crag 31 feet.

June 26, depression of lake 129 feet, depression of central crag 29 feet.

June 27, depression of lake 131 feet, depression of central crag 34 feet.

June 29, depression of lake 131 feet, depression of central crag 31 feet.

July 2, depression of lake 129 feet, depression of central crag 33 feet.

July 4, depression of lake 132 feet, depression of central crag 36 feet.

It will be seen that the net effect is a subsidence of the lake 3 feet in 13 days and of the crag 5 feet.

On Saturday, June 29, at 1 p. m., there was strong eastward streaming in the main lake, two spatter heaps were building on the south side of the east pool and two more on the north side, one of them a large dome. The central pool was constricted by the inward construction of its marginal shelf. A flaming chimney, following contact of spatter material and inner wall, glowed about 5 feet above the lake level at the central cove. The southeast pond was flush with its inner shelf and fountaining on its south side. There was bombardment at the west end of the southeast pond. During a sinking spell when the surface of the main lake sank about a foot, a migratory central fountain was seen. A freshly formed overflow of heavy festooned lava surrounded the eastern depression of the north lake. The southeast ledge was now covered with Pele's hair. Fumes were moderate. The noises on this day were from hissing border grottoes and pounding in the caverns, while occasionally a deep toned cracking noise was audible from the region of the east ledge. In general the condition suggested rising activity.

On June 30 at 3:30 p. m. the pit was more smoky, the crags appeared lower, the lake was active and spattering over its banks, showing eastward streaming and occasional large travelling or bubble fountains which migrated to the north corner of the east pool. The southeast and main pools stood 2 feet below their inner shelves. At 5 p. m. conditions were about the same and fumes were thick in the northwest part of the pit.

On the morning of July 1 the lake was reported low with deep overhang under the inner bench on all sides, with smoke abundant.

On Tuesday, July 2, at 3:45 p. m., measurements showed the lake to be higher and the crag lower. The inner shelf had widened and was covered with fresh overflow material and exhibited spatter domes. The height of the lake had gained on the chimney at the central cove. There was much smoke, fountaining was strongest against the northern banks of the southeast pond and the east pool, streaming was eastward in a broad zone and a fountain played against the south bank of the east pool. Toward the west-northwest there was hissing, but at the northwest cone, which had broken open, there was no activity other than a little smoke.

WEEKLY BULLETIN
of the
Hawaiian Volcano Observatory

Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

Smoke rose abundantly from the west pond cone. In the west arm pond an active breaking up was seen which developed much bubble fountaining. The southwest pond was streaming eastward and fountaining against its north bank, while a new glowing chimney hole, probably flaming and showing yellow margins, was seen to have formed in the rock tumble east of the pond over the site of the central valley tunnel and under the south side of the central crag mass. There was a triangular collapsed area in the southwest flows next to the wall of the pit. A black cavern of collapse had formed in the swollen flows to the south of the south crag. Glow could no longer be seen at the southeast cone. On Wednesday, July 3, the fume from the pit was much thinner.

Measurement on July 4 at noon showed that the north crag was rising and the central region was sinking. There were fresh overflows at the margins of the north and northwest pools, and at the north pool there was puffing. Fume had greatly diminished toward the northwest, but it was thicker west of the central region and about the southeast crevasses. In the main lake the streaming was from both east and west and the currents meeting at the central channel sometimes developed there a large fountain which expressed itself in bombardment of the north bank. At the central cove also there was bombardment and the chimney there stood only 4 feet above the lake. The inner shelf showed overhang and stood two feet above the lake. The southwest and southeast ponds were about as usual with some overhang of the inner benches. Sliding was heard in the south talus. There was no action at the northwest cone. The noises were of plashing, puffing and rumbling.

On Friday, July 5, 1918, at 10 a. m., there was little change in the activity. Several fountains at the margins of the main lake continued to build up the shoreline and there were new spatter domes on the northwest shore of the north lake and on the inner shelf at the north corner of the east pool back from the edge of the lake and over the site of the northeast tunnel. There was bombardment and hissing at the southeast corner of the southwest pond. Fume was moderate. A marked change first noticed on this day was the absence of the overhanging half of the south cone on the high edge of Halemaumau, which had now fallen into the pit, leaving this cone largely demolished.

July 13, 1918.—During the week ending Friday, July 12, 1918, the Halemaumau lava column has continued slow subsidence at a faster rate than before, the central crag sinking from July 4 to July 12 nine feet or 1.1 feet per day, and the lake 12 feet or 1.5 feet per day. The measurements were as follows:

July 4, depression of lake 132 feet, depression central crag 36 feet.

July 9, depression of lake 141 feet, depression central crag 42 feet.

July 12, depression lake 144 feet, depression central crag 45 feet.

The visible changes of the week have been few and inconspicuous so that there is little of interest to report with reference to day-to-day changes.

On Monday, July 8, 1918, at 3:30 p. m., the smoke was moderately dense especially from the northern part of the pit. A cone on the border of the north lake was hissing. Streaming in the main lake was westward continuously and this phenomenon, which is unusual, has continued throughout the week. There were numerous fountains, especially on the south side of the southeast pool. This pond had completely overflowed its inner ledge and so appeared higher, while the main lake was 3 feet below its inner ledge. The northwest pond was at a pit with walls 5

or 6 feet high. The southwest pond appeared 4 or 5 feet below its inner ledge and the lava was pounding on its southeast bank. The west arm pond was low and glowed quietly. There were hot and smoky sulphurous spots at the east crevasse and in the northeast and east talus. Fuming sulphurous cones were now distributed as follows: On the southeast floor, on the ledge west of the west arm pond, at the west pond site, on the north central floor and in several places near the northern ponds.

On July 9 at 11 a. m. the streaming in the main lake exhibited a broad zone of festooning skin moving westward from the central channel to places where the lava rushed under the north bank of the central pool. Sometimes there was bombardment of the northwest bank of the east pool. Almost all the time there was fountaining bombardment at the central cove, that is the southwest side of the east pool. A slight hissing was heard at the north lake, the main lake stood two feet below its inner bench, there were occasional very slight movements of the talus on the north and east, and the fume was thin. The general appearance was as of a stationary condition.

On Friday, July 12, however, the measurement at 11:30 a. m. indicated distinct subsidence. There was dense fume rising from areas southwest, west and north, and moderate fume from the floor and talus east and southeast. Westward streaming continued. There were four or five border fountains and the lake level stood 3 to 4 feet below the main inner bench. A second newer spatter bench stood about half way between the inner bench level and the lake. There were freshly broken down places at the eastern low crags of the central crag mass, at the northeast crag mass, on the west side of the northwest pond, and on the east side of the western crag mass. The subsidence had so tilted back the central crag mass that its northern and southern peaks were now again on the same level—recently the northern one had been the higher. Wrinkled black satiny skins were streaming westward from the central channel and the current ended against the bank on the north side of the central pool. The east pool was crusted over. Two fountains played at the base of the central crag and one at the central cove. A smoking cone stood on the inner bench on the north side of the east pool. At the southeast pond the inner bench was 4 feet high with fountaining caverns under it on the north and southwest sides. The southwest pond had a high inner bench and the lava could not be seen from the southeast rim of the pit. The southeast cone had become much stained and there was a sulphur stained area above the east end of the main lake.

At 4:30 p. m. the lake was relatively much higher, the inner bench had been completely overflowed on the north sides of the central and eastern pools and was wholly submerged in the southeast pond. This meant a rise of more than four feet since morning. There were numerous puffing marginal fountains and everything suggested renewed gas pressure.

The readers of the Bulletin will be interested to know that the staff of the Observatory has recently been somewhat enlarged and on July 1 was constituted as follows:

T. A. Jaggar, Director;
Arnold Romberg, Physicist;
Isabel P. Jaggar, Recorder;
John Pekelo, General Assistant;
Alex. Lancaster, Janitor.

During the past few months the Observatory buildings have been repaired and repainted and some added accommodation secured by moving one of the crater cabins to the Observatory grounds and partitioning off the southwest verandah. During the past week work has been started on construction of new masonry surveying stations at Halemaumau to replace those destroyed by the overflow of February-March last.

Experimental work in the seismological laboratory by Dr. Romberg continues and a new upright pendulum has been built along lines designed by the writer during the past winter. This pendulum is built with the project in view of producing an accurate instrument especially adapted to determining the direction from which local earthwaves proceed. The direct determination of direction, without the intervention of rectangular coordinates, appears to have been given little attention in seismology. Several records have already been obtained optically with this

instrument which show volcanic tremor, microseisms and tilt. The experiments in progress indicate definite directions for these several types of movement. It seems probable that the registration of these directions of movement for prolonged periods of time will yield new discoveries of great interest in connection with Kilauea and Mauna Loa.

The following report for the routine registration of the Bosch-Omori seismographs of the Whitney Laboratory of Seismology covers the period for the three weeks ending at 2 p. m. Friday, July 12, 1918:

During the week ending June 28 four local earthquakes have been registered as follows: June 22, 8:13 a. m.; June 24, 6:19 a. m.; June 25, 1:49 a. m.; and June 26, (felt in Hilo), 6:16 p. m. One teleseism was registered June 27, 4:25 a. m. Volcanic vibration increased from slight to strongish values during the week, and microseismic motion was strong June 26-27. Tilting increased to the north and fluctuated in the E-W component.

During the week ending July 5 three local earthquakes were registered as follows: June 29, 12:31 p. m.; June 30 (pronounced shock), 8:22 a. m.; July 4, 12:38 a. m. One teleseism was registered 8:34 p. m. July 2, which wrote a fine optical record on the rebuilt instrument and originated at about the distance of Chile. Volcanic vibration was moderate with some prolonged spasms and microseisms were of ordinary values. Tilting became excessive to the north and tended to the east, both components becoming stationary toward the end of the week.

During the week ending July 12 one local earthquake, felt here and in Hilo, occurred at 8:44 p. m. July 10, preceded by a smaller shock four minutes earlier. A teleseism was registered at 12:10 a. m. July 8. Volcanic vibration was slight during the week but showed some pronounced spasms on the afternoon of July 12. Microseismic motion was moderate. Movements of tilting fluctuated with tendency to increase towards the north and east near the end of the week.

July 20, 1918.—During the week ending Friday, July 19, 1918, the same generally stationary condition of the lava column has continued in Halemaumau with the liquid lake about 140 feet below the rim of the pit. The measurements were:

July 12, depression of lake 144 feet, depression central crag 45 feet.

July 15, depression of lake 137 feet, depression central crag 47 feet.

July 16, depression of lake 144 feet, depression central crag 45 feet.

Thus the lake rose 7 feet in three days while the crag sank 2 feet; then in one day the lake sank 7 feet while the crag rose 2 feet. Thus the alternation of movement of liquid magma and bench magma continues. Except for a marked appearance of rising of the lake on July 15, no significant changes have taken place.

On July 14 at 3:30 p. m. the streaming in the main lake was again eastward, fountaining was as usual, the inner bench was three to four feet high and there was some rock sliding in the south talus. From the southeast verge of the pit no fountains were visible in the north lake.

At 7:45 a. m. the next day, Monday, July 15, 1918, there was marked change in that fountains were visible in the north lake and the lakes generally were high and overflowing their inner benches, with puffing and splashing border fountains which were forming crescent-shaped spatter cones. There were six fountains in the main lake, two and sometimes three in the southeast pond, at least one in the south corner of the southwest pond, two in the north lake and one in the northwest pond. Streaming was eastward from the central pool and the main lake surface was greatly extended westward by overflow. Hot bluish smoke was rising from the west pond cone. There were two glowing holes through the inner shelf in the north cove of the east pool. The lakes were clearly rising but not the crags. About 1:30 p. m. the rising ceased and the lakes subsided some 5 feet; streaming changed to the west and at 4:30 p. m. the inner benches were 3 feet high. Fountaining was violent on the north side of the central pool and occasionally in the other pools. The east pool was crusted over with occasional cracking and foundering in the southeast corner. Smoke had increased.

On July 16 at 10:30 a. m. the streaming in the lake was west and north, the inner benches were higher, fountaining was ordinary and light puffing could be heard from the direction of the north lake. One glowing hole remained in the northeast inner bench. Streaming was northeastward in the southeast pond. The west arm and southwest pond were low and the streaming in the latter was southward. A heavy mass of spatter bench collapsed into the lake on the north side of the east pool. Examination of the northwest cone from the north station showed that the cone had broken asunder and the pieces lay on the talus below.

On July 17 at 7:15 a. m. the inner shelf was 5 feet high and the fume rather thin. Between 9 and 10 a. m. the lake rose until level with the shelf. At 12:30 p. m. it had again subsided about three feet and there were numerous border fountains spurting and giving evidence of considerable gas pressure. Streaming was westward.

On Thursday, July 18, at 5:30 p. m., no significant changes were discernible. The streaming was westward, four or five border fountains were playing in the main lake but no fountains were visible in the northern pools. The inner shelf stood three feet above the liquid, the northeast glow hole persisted, there were hissing noises from some of the grottoes, the southeast pond was crusted over and the southwest pond appeared relatively higher than of late. The pit was smoky.

On the morning of July 19 the lake rose from about 7 feet below the inner shelf to 3 feet below it. There was no evident visible streaming, the lake was mostly crusted over, the only fountaining being at the central cove. There was puffing towards the north. After 11 a. m. the lava was again subsiding. The southwest pond was crusted over and the southeast pond appeared 10 feet below the inner shelf. Smoke was still abundant.

The experiments in the seismological laboratory have continued during the week with improvements in sharpness of definition of optical registration, and tests with chronograph drums running at high speed. Work has been started in testing the constants of the standard instruments used for routine recording and in improving their registration appliances.

July 27, 1918.—During the week ending Friday, July 26, 1918, the Halemaumau lava column has continued stationary at a level depressed about 144 feet north, southwest and southeast. The usual slight alterations between risings and fallings of lakes and crags continue, the net result producing no essential change of level. The activity is moderate so far as fountaining, streaming and puffing are concerned, and four open lava lakes are in action, respectively in the center and at the north, southwes and southeast. The weather has been rainy and the pit consequently full of mist and fume. Seismically the present period is a quiet one.

The measurements were:

July 16, depression of lake 144 feet, depression central crag 45 feet.

July 26, depression of lake 143 feet, depression central crag 48 feet.

The general aspect of Halemaumau at present is much as it was a year ago, except that the open three-arm lake of that time is more constricted, the ends of the three arms being now separate ponds and the middle region is a longish lake of east-west trend. All four are sunk in inner pits twenty to thirty feet deep, and the margins of these pits are tumbled floors and uptilted crags. Several of the crags retain their identity year after year, and the oldest of them, the west crag, dates from August of 1916. The edge of the pit is much changed by the overflows of February-March, 1918, so that now it is a continuous unbroken circle of precipice rising 50 to 100 feet above the talus below. The talus is irregular, and has been replaced by fresh overflows on the west. The inner crags, which are in three principal bodies northeast, west and south of the center respectively, rise from 50 to 100 feet above the lake levels, and are tilted up scarps of floor matter or uplifted "islands." The highest of them now and for a year past is the south-central one, referred to as the "central crag," which at the moment of last measurement stood 95 feet above the central or main lake. The cones occasionally referred to in these pages are blowing cones built

above cracks in the floors or on the margins of the lakes by the sputtering of lava charged with gas, and some of these are over the sites of lava wells known by the experience of the past and recorded in the Observatory books. The inner benches are flood margins of the several lava pools, developed by inward building of the edges of the pools and overflowing of the banks during times when rising of the liquid relative to its banks prevails.

On July 21, 1918, at 4:30 p. m., the east arm of the main lake as seen from the east was quiet and crusted and the surface stood 5 feet below the inner bench of overflow; at 4:45 p. m. the crust broke up, bubble fountaining developed and the liquid streamed westward. At 5:30 p. m. a prolonged avalanche fell from under the new northeast fill and continued off and on for ten minutes. Small readjustments of the talus followed for some time afterwards.

On Monday, July 22, 1918, at 10 a. m., the southwest pond showed fountaining and the east arm of the main lake stood five feet below the inner bench and crusted over. One fountain played for a time in the southeast pond.

July 23 at 8 a. m. the inner bench stood eight feet above the lake, five marginal fountains were in action and the surface current poured westward to the grotto on the north side of the central pool. A central fountain and some bubble fountains played in the southeast pond.

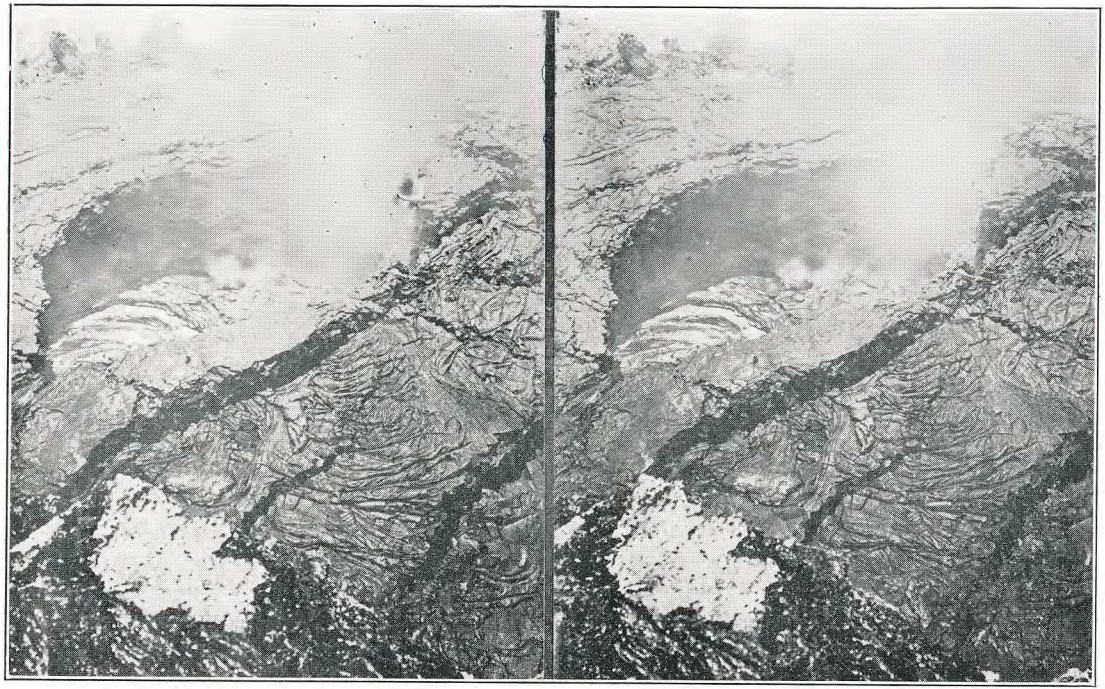
On the morning of July 24 from 9 a. m. until noon the lava column appeared quite stationary. There was sluggish bubble fountaining and some central fountains, and occasionally cracking and foundering of crusts took place in the main lake. The streaming was against the north bank. Bubble fountains were seen on the east side of the north lake and along the southeast side of the west arm pond. There was occasional violent fountaining on the south side of the southwest pond. The inner bench at the southeast pond and the east pool of the main lake was four feet high, but only two feet high at the central pool, as though the bench magma of the central part of the floor were sinking. There was some puffing noise in the fountains of the west and southwest pools. The greater part of the central pool area had now become a floor or plain, only the eastern half was an open cove. The marginal fountaining was against the north side of the channel (between east and central pools.)

July 25 at 4:30 p. m. the lake was relatively higher, two feet below the inner bench, and the reversed current now flowing southeastward gave evidence, along with all other signs, of a change to rising. There were active spatter grottoes along the margins of the main lake and in the southeast pond. At 5:30 p. m. great activity was noticed in the north lake, where five or six fountains played both along the margins and in the center. There was much smoke, however, which made it difficult to distinguish details.

Measurements Friday, July 26, 1918, at 9:30 a. m., showed that the lake had recovered to the same level as ten days before, but the crags were all very slightly lower. Relative to their margins the lakes all appeared high, the main lake standing only one foot below the inner shelf, with puffing border fountains incessantly changing position and in process of building spatter ramparts; there were four or five of them in the main lake and two in the southeast pond. The southwest pond was stagnant and crusted, but on the evening before a conspicuous flame was seen on its margin, a steady flare of burning gas. In the afternoon there was a heavy collapse of the bank of this pond on its southwest side. On this day it was very smoky and rainy. It was evident that another spasm of rising lake magma was compensating the slow subsidence of bench magma in accordance with the rhythmic action which has been the habit of the lava for many weeks.

Work on the new surveying stations at Halemaumau has proceeded rapidly so that five monuments are nearly finished. Each station consists of a level platform of concrete six feet in diameter with a concrete post in the center 2½ feet high. When finished they will be eight in number and oriented with reference to the meridian passing through nearly the center of the pit. The experimental work in seismometry continues with optical records as well

June 21, 1918. Lake and Central Crag, Halemaumau, from east verge of pit.



June 21, 1918. Southeast pond from southeast edge of pit.—*Photos Jaggar.*
[May be inspected with ordinary stereoscope.]

as the routine smoked paper records produced every night.

The following is the report of earthquake and other seismic registration in the Whitney Laboratory for the two weeks ending at 2 p. m. Friday, July 26, 1918:

For the week ending July 19 one teleseism was registered at 1:56 p. m. July 14, 1918, the preliminary phase indicating origin 2260 km. away, equivalent to the distance of Midway Island or the equatorial belt south of Christmas Island. Two very small local shocks happened 11:19 a. m. July 15 and 6:15 p. m. July 18. Tilting movements and volcanic vibration were slight, microseismic motion was moderate.

During the week ending July 26, a teleseism at 7:49 p. m. July 20 appeared to come from an origin about 6000 km. distant. There were small local earthquakes, 6:23 p. m. July 21, 1:58 a. m. July 24, and 2:29 p. m. July 25. Tilting showed slight tendency northward, microseisms were moderate and volcanic vibrations slight.

August 3, 1918.—During the week ending Friday, August 2, 1918, the Halemaumau lava has very slowly subsided with some increase of activity of fountaining and a deceptive appearance at times as though the lake were rising. The average rate of subsidence has been one-half a foot per day in contrast to a rate for the ten days preceding (July 16-26) of one-fifth foot per day.

The measurements were:

July 26, depression of lake 143 feet, depression of central crag 48 feet.

August 2, depression of lake 147 feet, depression of central crag 51 feet.

The week has been rainy and the pit much obscured with steam and smoke. On July 28 at 5 p. m. the inner bench around the east pool stood only one foot above the liquid and there was much fountaining under the north bank of that pool. The central pool was quiet on its north side but there were two fountaining areas at the base of the central crag mass. The north lake showed considerable activity but fumes in that region were dense. At 5:15 p. m. there was subsidence of the main lake about three feet with increased fountaining and a swift westward current. A half hour later rapid rising set in so that in twenty minutes the lake was flush with the inner bench and shortly after 6 o'clock it overflowed that bench on the northwest side of the central pool.

On Monday, July 29, at 10 a. m., the inner bench was one foot high and there were five marginal fountains along the south side of the main lake. Thin black skins covered the remainder of the lake. In the southeast pond the inner bench was four feet high and one fountain was in action. The north lake was level with its banks and marginal fountains were boiling there. At 10:30 a. m. a rock slide took place under the remains of the south cone.

On July 31 at 6 p. m. the general appearance of higher liquid lava, at least so far as relation to the surrounding bench magma was concerned, was very striking. There must have been during this time an actual rise of the lake, for some ponds and coves not previously visible came into view. Both the north lake and northwest pond were active and their surfaces in full view from the southeast station. A large cone had formed on the south bank of the north lake and a blue flame was playing through an orifice of this cone. The activity of the main lake showed high gas pressure with five spurting fountains at the inner bench level. There came a spell of breaking up when collapses of the bank on the north and west sides stimulated very rapid westward streaming; prior to that the streaming had been against the north bank. There was glow in the southeast cone and in the cone at the north corner of the east pool. The southeast pond appeared as usual with some blowing fountains and there was bright glow in the southwest pond. The northwest pond showed fountaining. The fumes were rather dense. In general the increased activity, appearing distinctly constructive in building spatter margins around the lakes, was puzzling, for other symptoms such as the fume and the crag positions indicated sinking rather than rising.

On August 1, 1918, at 5:30 p. m., the lake level, one foot below the inner bench, was unchanged and the main lake was quiet and crusted until 6:30 p. m. At that time the crust began to

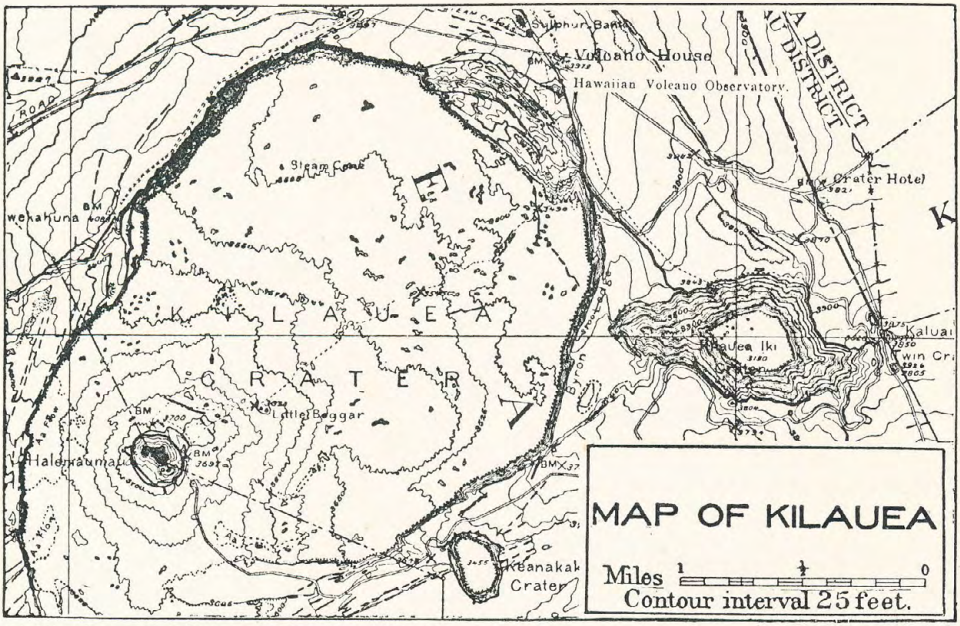
break up and streaming westward became rapid and tumultuous with great development of fountains. The north lake and the southwest pond also showed fountaining but the southeast pond remained quiet.

At noon on Friday, August 2, the measurements indicated slow subsidence of both lake and crag, although the lake was active and brimming level with its inner bench about the central pool. The pit as a whole was rather smoky. The southwest pond surface was now visible from the southeast rim of the pit, the northwest and north lakes were both visible and there were four or five fountains in the main lake at the bench level. A block of the upraised northeast floor appeared to have fallen from the crag overhanging the east end of the north lake and this now stood out as a pinnacle there. A considerable spatter grotto had been built up at the central cove (southwest side east pool). The southeast pond had become nearly circular and it appeared somewhat higher relative to the walls of its pit; a narrow inner bench of even width one foot above the pond surrounded it. There had been marked development of cracked and stained areas at the west pond cone and at the top of the inner cliff overhanging the south bank of the southwest pond, and both of these places showed increase of fuming.

During the week the first moulded concrete post, marking the new east station platform has been cast. The seismologic experiments conducted by Dr. Romberg have this week made definite progress along three lines of inquiry. A short period, highly damped, horizontal pendulum with heavy mass, recording optically on bromide paper running at high speed, has written a clear open record of a local earthquake. By relating the closeness of the lines written on the drum it has become possible to run such a high-speed record for the entire twenty-four hours each day without objectionable expense. The second accomplishment has been the discovery of a quick period vibration due to the arrangement of the heavy mass in the pendulum in question which must be a source of some instrumental error in all seismograms written by such pendulums. This arrangement was at once changed and the difficulty obviated. The third experiment has resulted in the construction of a new kind of stylus for the smoked-paper method, which promises to reduce friction. This consists in a lever made of an extremely light and fine glass tube with a minute sharp edge watchwork wheel rotating at the end in a glass bearing. The wheel itself is the writing pen and trials of its efficiency are in progress. In the course of tests of the two 100-kilogram Bosch-Omori pendulums, in order to determine experimentally the exact equivalence of their adjustments, the two instruments have been set up side by side so as to record the same earth motions in the same directions. They will be run for some time in this relation and careful tests will be made of their instrumental uniformity.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. All scientific exchanges should be sent to this address.

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, AUGUST, 1918 No. 8

HAWAIIAN VOLCANO OBSERVATORY.

August 10, 1918.

During the week ending Friday, August 9, 1918, the lava lake and crags of Halemaumau have risen in the pit with an extraordinary spurt which indicates that the long stagnant spell is finished. The rising of the lava column has been at the rate of at least 13 feet per day, the lake rising 85 feet in six days and the central crag 80 feet in the same time.

The measurements were:

August 2—Depression of lake, 147 feet; depression of central crag, 51 feet.

August 8—Depression of lake, 62 feet; elevation central crag above rim, 29 feet.

The manner of rising has been like that of last February and the entire episode closely resembles the remarkable rise of that time. Now as then the rapid spurt begins in the month preceding the equinoctial season. and if the present rapid rising were to continue the lake lava would be flowing over the edge of the pit before the end of August just as it did on February 23. The central bench magma has swollen up, the crags have tilted back, and the liquid has welled up the wall cracks as at that time, and even the forms and locations of the several features are similar.

On August 4, 1918, at 5 p. m., the lava of the east pool was level with the inner bench, two grottoes were boiling on the south side, and the southeast pond was quiet. From 5:30 to 6 p. m. the north and northwest pools broke into considerable activity with much fountaining.

On Monday, August 5, it became evident that lakes and crags were both rising and this sudden rise appears to have started on the preceding night. At 3:30 p. m. the central crag appeared much higher than at any time in recent days, and the northeast crag ridge showed increased backward tilt, the mass parting from the central floor crag along a crack extending from the northeast cove to the north lake. The inner benches around the main lake were uplifted and the rising talus under the east station was seen to be underlain by a block of lifting rock which slopes northward and tends to open the east wall crack and drop debris into it. The west crag mass had lifted so as to cut off the view of the west pond cone from the east station. All this jostling of crags was breaking down the partition between the southeast pond and the east pool, leaving a saddle of debris between them where rocks fell frequently. Everything indicated recurrence of central tumescence and radial tilt of the three sectors of bench magma away from the center.

That the lake magma was also rising showed at the southwest pond which was overflowing its southeast bank across what three days before had been a considerable inner cliff just to the east of the fuming cracks. Slight subsidence of about a foot succeeded the overflooding.

Because of smoke little could be seen of the northern lakes, but they appeared larger. The southwest pond ejected high spurts of lava at its south margin, and there were southern and northeastern fountains in the main lake and others on the south side of the southeast pond. The lakes were mostly covered with blistering and ballooning skins, and the fumes were thin as compared with the previous week. At 6:20 p. m. there was a heavy fall of bench matter into the lake from the point north of the narrows, leaving a notch 20 feet wide up to some 30 feet above the liquid. This produced violent fountaining. About 7:10

WEEKLY BULLETIN
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Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

p. m. there was another collapse into the southeast pond.

On the morning of August 6 the central crag had risen above the edge of the pit and was plainly visible from a distance. At 11 a. m. it was clear that the tumescence was going on rapidly. A fresh flow had poured from the cracks north of the north lake the length of the northeast valley. The tilting away from the center was augmented by subsidence of the wall valleys, especially east and northeast, where the depression was far below lake level. The inner benches had been lifted faster than the lake. There was much sliding and tumbling in the notch between the southeast pond and the east pool. Fountaining was rather tumultuous, and in the southwest pond it took the form of cracking and foundering spells between intervals of crusting.

On Wednesday, August 7, at 1 p. m., very rapid rising of the crags had continued so that everywhere they appeared uptilted in a chaos of scarps and slopes. This, with the sinking of the wall valleys, was so continuous that the talus was slipping all along the base of the east and northeast cliffs. The upraised crags now almost wholly cut off the view of the lake from the east rim of the pit, and the northern lakes were wholly cut off. The crag overhanging the east end of the north lake was now nearly on a level with the north crag by upward tilting, and in like manner the crag overhanging the northeast side of the east arm was becoming a conspicuous scarp, and a similar scarp had developed east of the southeast pond, tipping away from the new notch between the two pools. This notch continued to widen and crumble, with an unstable pinnacle poised in its midst. A fault chasm could be seen emerging on the central cove end of the crack which separates the central crag block from that south of it, the former tending to move up on the fault plane.

The activity of the lakes was of the usual blowing, spurting and blistering type such as commonly accompanies rising lava. There was strong streaming against the bank at the south and northeast grottoes of the east pool. The fumes were not especially thin.

On August 8, with the central crag 30 feet above the rim of the pit and the lake 60 feet below it, a great change had been wrought and everything suggested the conditions of last February. Inspection at 3 p. m. showed that the deep wall valley recently depressed opposite the east-southeast end of the lake had filled through the action of lava springs welling up from beneath until it was not far below the lake and a gas vent was hissing on the surface of the crusted fill. The inner northern crag was higher than the outer, and these, along with the west crag, had come into view above the edge of the pit as seen from the distant observatory. The central steeple, a pinnacle east of the central crag, was again becoming conspicuous and the pinnacle in the southeast pond notch remained high. The new fill in the south valley had been fed from the southwest wall cracks and extended to a point beneath the south station. A puddle of fresh lava under the north station was apparently fed from the wall crack near the northwest cone; the latter was hissing. The south end of the west crag mass was upraised into a westward dipping scarp, and the mass of elevated floor on the north side of the central channel was now a crag tilted northward. A new east ledge had been built by the rapid lifting of the south end of the northeast crag mass. All the wall cracks were yawning open and everywhere talus was in motion. The crag under the east station with edge trending east-west extending from the wall to the east ledge was an extraordinary creation of this uplift, its summit being now only 30 feet below the east station and the upward thrust causing it to form a barrier across the end of the northeast valley at right angles to the other con-

centric features. This ledge on its south side sloped into a rock-filled gulch which had begun as the large southeast crevasse of the May rising period. This gulch is an extension of the east cove of the lake corresponding to the old east gulch, and a small fresh overflow from the lake had poured into it.

The north lake was cracking and foundering, and dense white smoke rose from a crack west of it. A pool of fresh lava which had welled up the wall crack under the west station showed cracking and foundering crusts and was spreading. There was a smoky pit probably full of lava where the west pond cone had been. The southwest pond stood about three feet below its margin. The main lake was covered with heavy folded crusts. Blisters frequently formed, there was inrush to the bank on the south side of the east arm, and occasionally tumultuous bombardment took place. There were many lines of upraised spatter rim veneering the inner pit of the main lake, and this pit showed no sign of becoming shallower. The west arm pond was extended into a gulch leading to the foot of the west wall of the pit at the site of the former west pond and west cone. Everywhere were shown the effects of a swelling up in the center, while lava welled up the wall cracks and the lakes rose in the yawning chasms between the uplifted blocks but were prevented from overflowing by the equivalent rising of those blocks.

On Friday, August 9, at 9 a. m., the rising continued, there were trickling toes at the margins of the valley fills, and slides were numerous from the rapidly tilting crag slopes. About 11 a. m. a lava spring broke its way through the talus boulders of the wall crack under the north station and made a very liquid rivulet which poured east along the base of the wall, making a new fill at the margin of the northeast valley. The dense fume at the north lake chasm was conspicuous at 9 a. m., but disappeared two hours later. The lakes tended to crack up their crusts through gas pressure from beneath from time to time, this being followed by temporary subsidence of two or three feet. At such times there was violent hissing and spurting of fountains; this was observed in all the lakes. The principal streaming in the main lake moved in a curve from the central pool eastward and then against the south bank of the east pool immediately under the saddle and pinnacle separating that pool from the southeast pond. By the evening of this day all of the larger crags were in view above the edge of the pit as seen from the Observatory.

During the week the experiments in the seismological laboratory have resulted in registration of another teleseism optically and in highly magnified registration of local earthquakes by the smoked-paper method. New concrete supports have been set up in the instrument cellar for the slow period pendulum which is destined for permanent optical registration of distant earthquakes. At the pit, work on the masonry trig stations has continued.

August 17, 1918.

During the week ending Friday, August 16, 1918, the lava column has continued to rise, but at a much slower rate, averaging 4.3 feet per day. This means that the movement throughout the week has been slowing up, for the daily measures from the Observatory of the changing height of the crags showed almost a cessation of motion on August 15. In general, lakes and crags have risen together, the net movement of the week amounting to about 30 feet.

The measurements were:

August 8—Depression of lake, 62 feet; elevation central crag above rim, 29 feet.

August 15—Depression of lake, 30 feet; elevation central crag above rim, 60 feet.

On August 15 the wall valley fill under the north station was only 24 feet down.

On Saturday, August 10, 1918, at 9:30 a. m., a circuit of the pit beginning at the south and west revealed increase of wall-valley fillings with their edges pushing out in many places. A new west cone had developed in the depression southwest of the west arm pond. An overflow had poured from the south margin of the southwest pond. A cascade was running from the rapidly growing northwest wall cone into the northwest valley. There was much fountaining on the west side of the west arm pond, and cavernous grottoes were visible at the margins of the north and northwest pools. The fresh glowing fill of the northeast valley showed crusts in process

of cracking and foundering. Lava was splashing in a crack some distance to the north of the north lake. Streaming in the main lake moved from the west to terminate in bombardment at the south grotto and the northeast cove, but occasional westward streaming opposed the main current and developed traveling fountains at the central channel. There were hissing wall crack cones north, northwest, west and southeast. All the crags showed continued uptilting away from the center and much sliding of talus indicated continuing motion. The most rapidly moving crag was the one uplifted athwart the southeast end of the northeast valley with its trend at right angles to the main east ledge. It seems probable that this must be the uplifted remnant of the east gulch flows of last winter.

At 7 p. m. there was occasional cracking and foundering in the lakes, with violent fountaining and subsidence of a few feet. This in the main lake was followed by a rise with overflow of its east end so that a cascade poured down into the east valley fill. Meanwhile a ribbon cascade had been pouring along the base of the wall into this fill from a higher wall crack vent nearly under the new southeast station. The strong gas pressure developed beneath the glowing crust of this southeast fill caused bright blue flames to play over the surface of the crust, not at fixed cracks but on dark surfaces away from the glowing crevices. Apparently the gas was rising through crust pores. Sometimes the flames became bright yellow. In the main lake there were four or five large spatter cone grottoes, trickle flows continued to push out from under the wall-valley fillings, wall-crack cones northwest, north and southeast occasionally broke into spurting eruption and everything indicated continued rising without cessation.

On the morning of August 11 at 10 a. m. the crags were still rising with talus sliding, especially at the east cross ledge, and the wall valleys continued to fill. The main lake was building large grottoes south and northeast, and the southeast pond was higher, with widening inner bench. A new circular pond depression had developed around the southeast cone at the location of the former central pond, and as before a crevasse extended southward from it. A long crack extended from it in a nearly straight line to the southwest pond, marking probably the south tunnel. The streaming in the southeast pond was southward and in the main lake eastward and southward. The northeast crag mass was again becoming an upright wall in full view from Volcano House, and the north inner crag was now much higher than the outer one. The cone at the north wall crack was spurting continuously and ejecting a cascade of lava which poured eastward. The vent at the southeast wall crack was flowing sluggishly. The activity showed few changes, there was high gas pressure, cliffs 50 feet high stood over the main lake, and the fumes were thinner.

On Monday, August 12, at 10 p. m., all signs of rising continued as before. There was a flaming filagree cone built high against the wall on the south side of the southeast pond and six-foot banners of flame shot out from the grotto on the south side of the east arm. There were now seven ponds in the pit, respectively the main and north lakes, the southwest lake (consisting of southwest and west arm ponds united), and the west, northwest, southeast and central ponds. In addition, there were four marginal wall valley fillings of crusted lava fed by wells beneath, namely, the east, northeast, west, and south fills.

On August 13 at 6 p. m. it appeared that the southeast pond had overflowed into the east fill, there were grottoes with stalactites on its west side and in the northeast cove of the main lake, and a large spatter grotto had been built on the south side of the east arm. The tunnel connection from the southeast pond to the east arm appeared to lie under the northeast bank of the pond. From the west rim of the pit the central uplift was very impressive and the slope away from the center of the uplifted crag masses had developed with extraordinary rapidity, so as to produce the same effect of inner dome with lake concealed in its chasms and crevasses as was so striking last March. The main lake is nowhere visible except from the southeast. The hot fillings of the wall valleys were interrupted at only two places—one west and the other east. The south fill had recently been supplied by overflows from the southwest pond, which was fountaining violently against its

south bank. The west cone was a low flat arched dome glowing inside. The ponded fill of the west valley had a flat surface and the great ledges which had slipped down in April under the west niche were almost completely submerged. The west pond was a deep chasm in the middle of the west crag mass showing the glow of activity within. The sliding slopes adjacent to the many crags gave evidence of rapid motion. The northwest cone, flaming and hissing, was built high against the wall of the pit. The northern ponds were very active. Under the old north station a horseshoe cone vomited lava beneath the crust of the northeast fill, which stood only 30 feet below the similar fill of last March. The main lake appeared high with its surface crusts drifting southward from both east and west ends and occasionally great balloons of skin were inflated from below.

On August 14 there were further overflows from the southeast and southwest ponds, and in the evening intense activity at the northwest cone produced a flood of lava which poured eastward the whole length of the northeast fill, raising the level of that ponded depression to within 15 feet of the March level.

On Thursday, August 15, 1918, at noon, the northeast crag mass was in motion with slides tumbling down its backslope. The north cone was low and hissing. The northwest cone had been built up to the level of the brink of the pit a few paces west of the old north resthouse and exhibited at that level several glowing, hissing and flaming orifices. Spatter from it lay on the rocks adjacent. The fill beneath was now higher than the northwest fill by some 15 feet of slope. The crags were all higher and the east ledge now wholly cut off the view of the central crag from the east shelter. The southwest pond stood two feet below its margin, the main lake and southeast pond three or four feet down, the activity was moderate, and the crust of the east fill had collapsed some six feet below its maximum level. This was the first sign of diminished gas pressure in the border fills and this checked with cessation of rising of the crags which took place on this day. Beneath the new south station the fill was only 20 feet down. This and the northwest cone locality appear likeliest places for overflows of the pit. The northwest cone was now in condition to overflow the rim at any moment.

In the Whitney Laboratory of Seismology the last stage of the summer's overhauling under Dr. Romberg has now been entered upon. This consists in setting up and adjusting the rebuilt instruments for the routine of the coming autumn and winter. The two Bosch-Omori seismographs will be operated with higher magnification, quicker moving drums and improved styluses. The registration of these instruments will be continued with smoked paper, and the new damping device consists of vanes moving in oil. This pair of instruments will record east-west and north-south components of local earthquakes, microtremors and microseisms or distant earthquakes. In this on a single drum. The time-marking device for minute marks and hour marks accomplishes with electro magnets positive lift of the scribing steel points so as to make gaps in the written line. Thus the clock time may be read directly from the seismogram and the correction for parallax is eliminated.

The second rebuilt apparatus is the Omori heavy pendulum now to be set up in the northeast-southwest azimuth as a one-component, slow-period, optically-registering instrument exclusively for teleseisms or distant earthquakes. In this instrument the iron pier has been eliminated, pivot friction is entirely removed, and the heavy mass hangs as a rigid unit on very short steel wires. By swinging the pendulum in this plane and from the rigid concrete of the corner of the cellar, it is hoped to make the free period of the pendulum slower and to reduce tilt and local tremors to a minimum.

A vertical component instrument and a special device for recording tilt are planned, as well as certain simple instruments designed to be placed in the hands of volunteer observers elsewhere on Hawaii.

August 24, 1918.

During the week ending Friday, August 23, 1918, the rising of the bench magma or lava crags has ceased and they have slightly subsided. The liquid lava has continued filling the wall valleys slowly on the southwest, northwest and northeast, but the southeast wall crack and east fill have slumped. The building up of the fillings on the north and south-

west has come within a few feet of overflowing the pit rim as in February, and this upbuilding has not yet stopped. A sudden spasm of flowing might at any moment produce overflow at the southwest margin of the pit, for the driblet heap there, close to the edge for the length of a hundred feet, stands six or eight feet above the level of the edge and the flows from it are within a foot of going over. The lakes have maintained their depression 25 to 30 feet below the rim of the pit throughout the week.

On Saturday, August 17, 1918, at 6:30 p. m., the wall cracks south and east were found to have slumped while the valley fillings adjacent to them had swollen in dome fashion so as to make surfaces curving downward into the wall crack. Strong swelling was going on in the northeast fill, and lava flows were there pushing from under the crust at the east end and around the sides. Hissing gases burned from under a hinging lid at the northwest cone and the north cone was also hissing. Slides still fell from the back of the northeast ledge. There was fountaining in the northern ponds; the main lake was low, showing a tunnel at the northeast cove. There was eastward streaming and but slight activity. At 8:30 p. m. there were five or six fountains in the southeast pond, and the liquid was nearly level with the inner bench; the main lake was also high and active, and the southwest pond during the evening rose nearly to overflowing. At 9 p. m. there were more than fifteen driblet flows in motion about the northeast fill. At 10 p. m. the northwest cone had burst open and was ejecting spray thirty feet or more. There were small flows in the west wall valley.

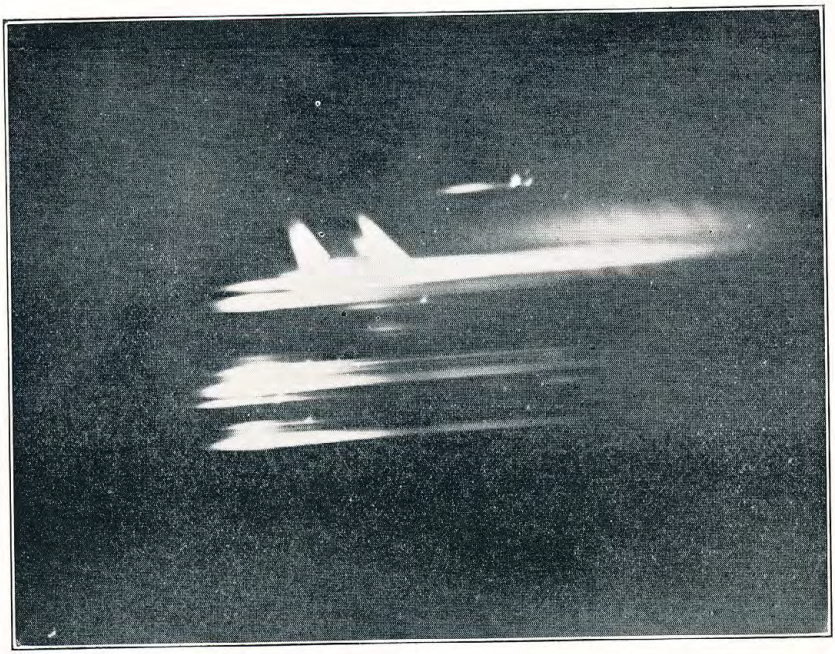
On August 18 at 3:30 p. m. the swelling of the wall valley floors continued, so that the general level of the northeast fill was flush with the lower portions of the northeast shelf. The west fill was not quite so high. The northwest cone continued puffing and flaming. The south fill had swollen up somewhat, but the wall crack vent southeast was now a depression of collapse and the east fill a marked depression 40 feet below the southeast edge of the pit, with irregular slumped and blistered crusts for its floor.

The main lake appeared relatively low, and the southern and eastern grotto heaps now stood more than 10 feet above the liquid. There were tunnel grottoes at the northeast cove and on the west side of the southeast pond. Streaming was eastward and southward. The writer crossed the north fill without difficulty, and penetrating among the crags of the north lake found in the enclosure only tumbled rocks with both the north and northwest ponds small and inactive and six or eight feet below their margins. The floors of the wall valley fills were now easily accessible in many places and from 10 to 30 feet down. Balloons of crust and sudden heavings were notable on the north side of the main lake. Trickle flows continued to move about the northeast fill. At 5:30 p. m. the southeast pond was depressed five feet below its inner bench and very inactive. A large piece of its northwest wall fell in and started fountaining.

On the evening of August 19 the lakes were still low and sluggish with occasional explosive and ballooning bursts on the north side of the main lake. The lava fills were quiet, showing glow in the cracks. A heavy fall of rocks was reported from the north side of the central crag mass. The northwest cone was puffing occasionally. The crags were nearly stationary or slightly lower.

At 9 a. m. Tuesday, August 20, the lakes were sluggish, showed occasional fountains, and stood from 8 to 10 feet below their inner benches. The northeast fill had slightly overflowed the sunken portions of the February shelf northeast. The northwest cone was higher and stood four feet above the edge of the pit. The northwest fill was now level with the north fill, showing fresh flows and glowing crust caverns. The crags were stationary. The south valley filling showed increased arching downward toward the wall crack. The west cone depression in the southwest part of the pit had been built up by driblet flow construction to within one foot of the rim of Halemaumau opposite the great southwest crevasse. Two high puffing cones were constructing and flows were moving over a glistening pile of snaky pahoehoe which extended toward the west arm pond. This region suggested the conditions at the south cone in March, when great quantities of lava from such a driblet heap poured southward from Halemaumau for weeks.

On August 21 at 6 p. m. the main and



Aug. 23, 1918. Flame of burning gas photographed through spectroscope prism. Northwest cone, 10 p. m., flames 5 inches long. The bright bands are spectra of the melt. Wratten Panchromatic Plate. —Photo Jaggar.

Aug. 23, 1918. Direct photograph with Wratten Panchromatic Plate of pale yellow green flames 5 inches long, 5 feet away. Northwest cone, 11 p. m. High gas pressure. The camera was set up on the side of the cone.

Aug. 23, 1918. Northwest cone where flame photographs were taken

southeast lakes showed stalactitic overhang, bright fountaining and westward streaming. Some thirty feet below the southeast edge of the pit, these lakes were now barely visible owing to the uplift of the ramparts in front of them. The northern fills were glowing, and the north, northwest and west cones flaming and hissing. The southwest driblet pile was spurting and lifting a lid and emitting trickle flows fully six feet above the level of the edge of the pit. These poured into the southwest crevasse, making organ pipe cascades. Only a few feet more filling here would send an overflow down the long slope of the greater crater towards the desert. The southwest pond was spurting violently, but its surface could not be seen. There was activity in the northern lakes. The northwest cone had a filagree of glow cracks facing north on its summit, through which pale yellow flames of burning gas played with noisy blow-pipe effect. The crags were stationary.

On Thursday, August 22, at 11 a. m., activity had diminished, the pit was quiet and the crags stationary. The lakes appeared relatively higher, the southeast pond with an inner bench two feet high and the main lake six feet high. Toward a large fountain near the east end of the lake the surface currents streamed from both west and northeast. The wall cracks east and south had greatly slumped, but west and north upwelling was the rule. For a hundred feet of the southwest edge of Halemaumau the driblet flows were flush with the rim and the three cones stood high above it. There was great heat in the whitened March bench adjacent to these cones. No changes were apparent west and northeast, and the northwest cone puffed harshly. About 5 p. m. the lakes showed the usual fluctuations of activity and a tumble of rocks fell into the north lake. At 6:30 p. m. a prolonged flow started from the region of the northwest cone and extended itself the whole length of the northeast fill.

On Friday, August 23, at 6 p. m., the principal changes were increased steady gas pressure at the northwest cone with three spears of flame motionless and continuous. The nose of the blast was deafening. This increased gas pressure was accompanied by more flowing in the north and northeast fills. The writer climbed to the summit of the east crossledge for a view of the main lake. The lake showed eastward streaming and a large fountain at the east end. There were now more pronounced coves northeast, southeast, south (central cove), and at the central pool. Beside the high spatter dome at the southeast cove there was a pot flaming sluggishly and another chimney with fluttering banners of flame occupied the southeast wall of the southeast pond.

From 9 to 12 p. m., assisted by Dr. Romberg, and with the aid of a direct vision spectroscope loaned by the College of Hawaii, the writer took photographs and experimental photo-spectrographs of the continuous flames at the northwest cone. It was possible to approach within five feet of these flames and photograph them in profile against a dark background. The flames were about five inches long. The flame spectrum visually showed chiefly the sodium lines in a dark field when the flame was examined from a position which entirely cut off a view of the glowing melt. When the melt showed, the bright lines of the gas appeared against a continuous spectrum from the incandescent lava. An interesting method of identifying flames in the glowing cracks, where the incandescence was so bright as to visually conceal them, consisted in inspection of the flaming cracks through the prisms with both telescope and slit removed. The flaming gas now appeared pale yellow in natural form, while all the glow material appeared as formless parallel bright spectrum bands. The flames occupied the yellow zone of their own spectrum in each case, and an exceedingly faint band containing the green and violet could be traced extending from the flame image. This test for locating flames was applied to the fountains and grottoes of the lake and no trace of flame could be detected. When applied to the southeast pond chimney the flame again appeared in sharp outline. The illumined fume of the pit gave a continuous spectrum like the melt but less bright.

In the Whitney Laboratory the Bosch-Omori instruments have now been set up so as to write on a single drum, and the optical seismograph has also been placed in position and first tests made.

August 31, 1918.

During the week ending August 30, 1918, the first phase of the recent rise of the Halemaumau lava column had come to an end and the lava slightly subsided to a stationary condition, which continues at the present time. The lakes lie 30 to 40 feet below the rim of the pit, and the central crag stands about 60 feet above the rim. The activity of the week has been dull, blowing and flowing at wall valley cones has ceased, and while there are bright displays of fountaining in the main lake at night, such activity can be watched only by climbing down and crossing the wall valley. This stagnant spell appears to correspond to the temporary depression which took place in the first week of March last, prior to the strong rising of the equinoctial period.

On August 23 a fresh glowing flow was observed in the crevasse south of the southeast cone. On Saturday, August 24, about 8 p. m., there was an active pond in the extension of this crevasse near the southeast cone. The lakes showed increased fountaining and were relatively higher, while the crags were lower. The north wall valley showed a large turtle-back flow of fresh lava which had swollen up on the floor under the old north station and stood only 6 feet below the rim of the pit at the old north shelter. The northern ponds were active, with very high spraying fountains in three distinct depressions among the inner crags there. These local crags appeared to have risen. The west and southwest ponds were also active. The northwest cone continued to show shrieking jets of burning gas, but the upper flames had encased themselves in glassy spiracles and stood out as bluish petals around a rosette of minute orifices. When the spiracles were broken off with a stick the larger flames were restored along with the harsh hissing as before. On this night the spectroscope experiments were continued.

On August 25 at 4 p. m. the inner bench at the southeast pond stood five feet above the crusted lava surface and the east arm of the main lake was similarly inactive and low. About 6 p. m. there was breaking up and considerable activity, especially at the northeast grotto, while central fountains occasionally sprang up.

On Monday, August 26, at 11:25 a. m., the valley fills had slumped somewhat. The pit was quiet with subsiding tendency. The lakes stood 8 to 10 feet below the inner benches; their surfaces were crusted, but moderate border fountains broke through the crust now and then, with hissing at the start. There was bubbling in the southeast cone pond and much blue fume from live lava in the crevasse south of it. On crossing the south wall valley to the edge of the southwest pond the writer found the latter occupying a pit bordered on its north side by an inner bench 8 feet high, and on its southwest side by a lifted scarp 15 feet high. The channel extending eastward from it was floored with a tumble of rocks, had a width of 6 to 8 feet, and was overhung on its south side all the way to the southeast pond by an eastward extension of this southwest pond escarpment. The southwest pond was crusted over, but a fountain broke into action in the channel leading into the west arm pond.

The southwest border heap showed no activity and was now about 4 feet above the rim of the pit and from 15 to 20 feet higher than the west and south valley fills. In similar fashion the north "turtle-back" heap stood 8 to 10 feet higher than the northwest and northeast valley fills. The northwest cone could be heard bubbling inside as though its interior were a hollow chamber. There were occasional flame puffs from it, but the orifices were becoming sulphur stained; glowing cracks were numerous. Occasional fountaining noise was heard from the north lake.

The writer clambered from the east shelter through the tumbled eastern wall valley gulch and then crossed the east fill to the edge of the main lake. The latter was crusted over but periodically heavy bursts of gas broke the crust on the north side of the central channel and produced a rhythmic border fountain. There were other such fountains northeast and south with streaming to the grottoes. A raised spatter dome at the east end four feet above the lake level, and separated from the lake by a lower bench, contained an open flaming oven on the lake side filled with glowing stalactites. The lake was heavily sluggishly

two feet below the innermost bench, but around most of its margins there were vertical cliffs with spatter lines 8 to 10 feet high. The southeast pond was also visited and found streaming southward to grottoes which splashed on its southeast side; the crusts were cracking and foundering. The shelf east of it stood 6 feet above the liquid. A visit to the southeast cone depression revealed only a maze of tumbled cracks, with live lava rumbling and blue fume rising only in the south crevasse. The southeast driblet cone still stood in place unaltered by its depression and the chaotic chasms about it.

On August 27 at 9 a. m. the pond margins appeared 10 feet above the pools and these were very quiet except for the outbursts on the north side of the main lake. The crags were subsiding slightly and the smoke growing thicker.

On Wednesday, August 28, at 6:30 p. m., there was little change. A large fountain was playing near the east end of the main lake, and all the pools were moderately active, including the west pond chasm and the south crevasse. The cracks of the valley fills still glowed, and the northwest cone now had open window orifices, through which flames flared up and rumbling, gurgling lava could be heard within. The southwest heap was glowing and one orifice was flaring there. The fumes were rather dense. A slab was heard to fall near the southwest pond.

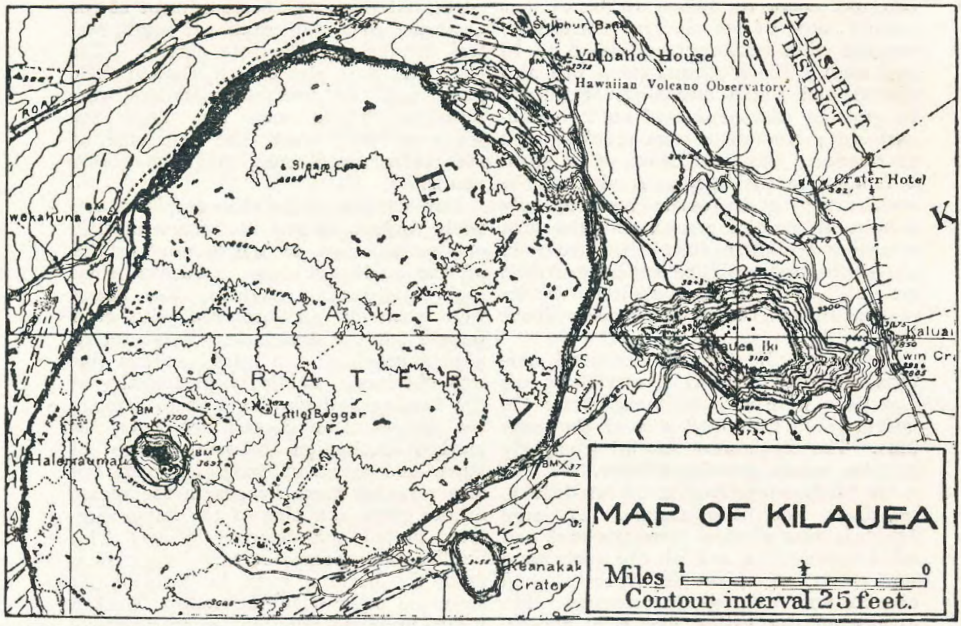
On Friday, August 30, at 11 a. m., everything appeared low and stagnant. There was bright flaring at night. The crags were somewhat lowered. The lakes were nearly concealed within their ramparts, but there was bombardment at the northeast cove and occasional bright central fountains broke into action. The northwest cone was broken, showed little glow, and the interior stalactites were revealed. Thick fume rose from the southeast wall crack, the east side of the central crag mass, and many other places.

Development of the photographic plates made August 23 and 24, with and without spectroscope, at the flaming orifices of the northwest cone, produced some highly interesting pictures. The flames were positvely photographed with clear images for the first time. Furthermore, a photograph of the bright sodium line was obtained. Lastly, a photograph of the flaming and glowing orifices through the prisms alone showed not only the marked distinction between image of flame and spectrum band of melt, but also revealed flame images in the region of the green and blue of the flame spectrum proper, not detected by eye. This implied the presence of faint bright lines from the burning gases in parts of the spectrum other than the yellow. Such a result promises possibilities of spectrum analysis in determining change of gas composition at different or consecutive times at volcanic vents.

In the Whitney Laboratory of Seismology the instruments have been settling down to renewed continuous recording, and the optical apparatus promises to do good work. Dr. Romberg has made some important improvements during the week.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

		Expressed by accelerations measured in millimeters per second per second.	
I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, SEPTEMBER, 1918 No. 9

HAWAIIAN VOLCANO OBSERVATORY, Sept. 7, 1918.—During the week ending Friday, September 6, 1918, the Halemaumau lava column has behaved just as during the preceding week, with slight settling of the crags and moderately active lakes, the latter showing some tendency to increased gas pressure and construction of spatter margins. The crags remain in full view from Volcano House, and the smoke from their midst is rather dense. No noteworthy change of level has been recorded. This kind of activity checks with what happened last March before the equinox, when the rising of the lake from March 5 to March 8 was accompanied by stationary crags and thereafter the crags rose rapidly and continued to rise until the 26th, when strong sinking set in. The past week has been seismically quiet.

On Saturday, August 31, 1918, at 10 a. m., both lakes and crags appeared relatively low, general conditions were unchanged, and there was nothing new on the west and southwest. The main and southeast lakes were barely visible 40 feet below the rim of the pit, and the central crag towered 100 feet above them. Inspection of the north lake hollow showed that the pond there was low amid tumbled boulders and smaller inner crags. There was slight rumbling under the northwest cone.

On September 2 from 5 to 6 p. m. the stagnant condition continued, the crags were stationary, some glow could still be seen in the cracks of the valley fills, much smoke indicated the presence of open cavities below, and all the ponds occasionally showed sufficient glow to indicate general activity in the lake magma. At the northeast cove some bombardment with spraying suggested renewed gas pressure in the liquid. There was no pressure, however, at the northwest cone. The main lake was streaming from its western end toward the south and northeast grottoes, and curtained grottoes heavy with stalactites occupied the northwest side of the southeast pond, and occasionally high fountain flings were thrown up from the north lake. Sinking spells occurred as usual, with cracking and foundering of crust, followed by bubble fountaining.

On Wednesday, September 4, at 7 p. m., there was distinct increase of activity in the lakes, with puffing and spraying from border fountains. The streaming in the main lake was in a broad curved river-like zone which emerged from the tunnel on the north side of the central pool and proceeded the length of the lake in an "S" shape to the east and south. Stalactite grottoes were common to both the southeast pond and the main lake, and there was bright flaring from the southwest pond. The bright zigzag lines between skin areas over the main lake had reappeared instead of the dark crusts with angular cracks which have been much more common of late. One rock slide was seen falling from the east cross-ledge, indicating motion in the crags. A gaping crevasse in the new northeast fill parallel to the wall under the east shelter showed glow 15 feet down. This and measured slight depression of the crags indicated that the renewal of gas pressure, heating and melting processes in the lake magma was being compensated by settlement of the bench magma blocks.

On September 5 from 6 to 9 p. m. there was the same sort of activity and an increased number of border fountains, with spraying and building of spatter ramparts. A large active dome grotto with immense stalactites had been built above the northeast cove, and about 7 p. m. a long block of the spatter bench

WEEKLY BULLETIN
of the
Hawaiian Volcano Observatory

Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

on the north side of the main lake collapsed and produced much commotion in the lake during a sinking spell. The skin was ballooned and blistered by gas near the entrance to the northeast grotto, but elsewhere large crust areas were sliding over each other eastward. Streaming was from the central region to the northeast grotto, but when the south grotto suddenly broke into action with much blowing and spraying there was insuck to the bank in that direction. Streaming in the southeast pond was southward. There was great increase in slipping of rocks from the southern slope of the east cross-ledge. Many smoking areas had developed among the cracks in the crags. On the next day, Friday, September 6, conditions were unchanged.

In the Whitney Laboratory of Seismology, Dr. Arnold Romberg this week concludes his summer season of experiment and reconstruction of instruments, and the director of the Observatory takes this opportunity to express his high appreciation and that of the Research Association for the excellent work which Dr. Romberg has done. We are now equipped with four instruments especially suited to the conditions here, and designed distinctively for local earthquakes and micro-tremors, for tilting of the ground and for teleseisms. During the week the clinograph or tilt-recording instrument has been set up, a horizontal pendulum with boom 10 feet long and a natural period of 72 seconds when undamped, and without lever complications. This instrument is writing on smoked paper with clock-work which moves the paper only about two inches in twenty-four hours, so that the east-west component of tilt will be recorded strongly and measured with ease. The pendulum is hung wholly from hinges of fine taut steel wire and fitted with a micrometer adjustment for direct test of magnification under tilt. An instrument for determining the vertical component of the motion of local earthquakes is being constructed, and experiments in special study of volcanic micro-tremors will be continued.

HAWAIIAN VOLCANO OBSERVATORY, Sept. 14, 1918.—During the week ending Friday, September 13, 1918, the lava column has slowly subsided one foot per day and the activity of the liquid lava has exhibited little change from what went before. The lakes have risen and fallen through a short range, with some building of openwork grotto roofs, but the general situation has been continuation of stagnant conditions without pronounced movements of any sort.

The measurements of elevation of the central crag above the rim of the pit for the past month were as follows:

August 20, 1918 — Elevation central crag above rim, 58 feet.

August 30, 1918—Elevation central crag above rim, 61 feet.

September 10, 1918—Elevation central crag above rim, 51 feet.

September 13, 1918—Elevation central crag above rim, 47 feet.

There was thus in the bench magma a rising August 21-30, for ten days, averaging .3 foot per day; August 31-September 10, eleven days, depression averaging .9 foot per day; September 11-13, three days, depression averaging 1.3 feet per day. The main lake has stood about 95 feet below the crag summit, and at present is therefore approximately 50 feet below the rim of the pit.

On Saturday, September 7, 1918, at 7 p. m., there was little change and the crags were stationary or slightly settling down. Streaming in the main lake was towards the northeast grotto and in the southeast pond towards its northwest side. Large crust areas covered the lake, the blocks sliding over each other as they moved eastward with the current. There was violent continuous blowing with flame and spatter at an orifice above the east end of the lake. No sliding was noticed at the east ledge, smoke

holes were many, and there was glow in all the ponds.

On September 10 at noon the lakes appeared somewhat higher with built-up margins and great quantities of Pele's hair on the east ledge attested constructional spraying activity. The spatter margin around the southeast pond was high, with a grotto dome formed on the west side. The large dome of the northeast cove had broken down, but there was a smaller one west of it. Near the southeast edge of the main lake a central fountain threw up high viscous flings of melt.

The northeast fill showed a sagging surface, but its border against the wall of the pit was a pressure ridge surmounted by deep crevasses. These wall cracks extended through the northwest cone which was thus broken in two; the interior cupola was lined with heavy stalactites and appeared to have a flat floor without any deep well beneath. The feeding conduit may have been a relatively small gas crack. A pressure ridge apparently surmounting a tunnel extended along the wall crack eastward from the cone. Another crevassed pressure ridge had formed across the wall valley opposite the gateway between the outfacing slopes of the northwestern crags. The north lake depression seen through this gateway showed crusted lakes without evident activity.

On the southwest side of the pit the filling of the gate depression west of the west arm pond had subsided greatly, but the cones near the wall of the pit and the southwest heap still stood at a high level though they showed slumping. There had been slumping also along the line of the chasm between the southwest pond and the southeast cone depression. The bright yellow sulphur stain had developed at a very hot fuming crack on top of the cliff bounding the south side of the southeast pond; there was similar stain also on the east side of the northwest cone. Smoke holes had developed in the southeast cone crevasse and at the southeast wall crack, adding to the general fume, which was dense. The gas pressure on this day was moderate.

A circuit of the pit by the east and north sides at 5 p. m. Thursday, September 12, showed the eastern lakes to be relatively high with active border grottoes and without overhanging margins. Streaming was eastward and fume had somewhat decreased. The pinnacle between the southeast pond and the main lake had collapsed. There was a large gaping crevasse parallel to the wall of the pit in the bottom of the east fill; the wall crevasse under the east shelter had widened and hot air was rising from it, but no glow was visible. Fumes rose from the site of the former north cone and from the wall crack east of the northwest cone. The latter had broken open still farther by the gaping of the wall crack so as to show a complete cross-section of the interior of the cupola. The north lake was now a glowing molten pond. The northern escarpment bounding the depression which contains the northern lakes was lower so as to exhibit more of the interior crags and pits. The north valley fill, however, was still swollen up close to the level of the rim of the pit. The west crag escarpment was now a long wall standing high above the main lake as seen from the east, with the old west crag knob surmounting it. A smoking patch had developed in the middle of the west fill. The southwest depression was now about 25 feet below the rim of the pit. The west arm pond was fountaining continuously and noisily, with much spraying. From the tube extending from the south cone on the rim of the pit, where many of the overflows of March, 1918, had their origin, white water vapor clouds rose in abundance through the broken cone orifice.

On Friday, September 13, 1918, at 5 p. m., there was no material change in appearances, but the fumes were notably thinner and the lakes continued high and active. There were seven fountains in the main lake, two or three in the southeast pond, and spatter ramparts were building in places. Glowing filagrees of flame holes surmounted the south grotto of the main lake and the west grotto of the southeast pond. Hot solfataras with sulphur stain and puffing fumes had formed on the south side of the east cross ledge, at the southeast wall crack, and at the southeast cone crevasse. The southeast cone was still in place. While there had been recently pronounced subsidence of the small southeast crags, the east fill, the middle part of the north-

east fill, and of the southwest depression, yet the broad fields of humpy lava occupying the south valley appeared swollen and the crags appeared as though the central units had subsided more than the outer ring. Streaming in the main lake was irregular but generally eastward, and occasional central fountains showed much spurting and spraying, while the marginal ones made rumbling and puffing noises. The main lake had contracted through the crusting of the western part of the central pool, where a tunnel arch leading northward had formed, and out of this poured the surface stream of the main lake in a broad zone eastward.

In the Whitney Laboratory of Seismology the week has been a notable one in that three pronounced seismic movements have tested the new instruments satisfactorily. At about 7 a. m. Saturday, September 7, the tremors of a powerful "world-shaking" earthquake agitated the seismographs and the optical instrument wrote a very complete and clear record of the phases. The evidence pointed to an irigin to the southeast at a distance of about 6000 kilometers. About eight hours later a pronounced earthquake-wave raised the waters of Hilo bay some four feet and was observed in the Wailoa river as a heaping of the waters which tore sampans from their moorings. This would check consistently in time of transmission of the water wave with the distance and time of the recorded teleseism originating somewhere under the Pacific to the southeast.

The next morning, September 8, about 7:40 o'clock, a local earthquake felt generally in the southern part of the island was admirably registered on the quick-moving drums of the rebuilt Bosch-Omori instruments, showing for the first time in routine registration at this station every detail of the timing and amplitude of the first preliminary tremor of a felt local earthquake.

The clinograph was adjusted on September 11 so that the smoked paper under the writing point moved at the slow rate of only 3.5 centimeters in twenty-four hours. On September 12 a pronounced tilt to the east was beautifully registered by this instrument and checked by the Bosch instruments, which indicated that the movement was to the south also. Thereafter the clinograph showed for two days tendency to accumulated westward tilt, with the diurnal curve clearly expressed as a pronounced sinusoidal line with a range or double amplitude of from 5 to 7 millimeters, the maxima of the eastward movement being reached about 8 a. m., and of the westward movement about 6 p. m., with considerable fluctuation. The westward movement was for this short period much more rapid than the eastward.

HAWAIIAN VOLCANO OBSERVATORY, Sept. 21, 1918.—During the week ending Friday, September 20, 1918, subsidence continued as measured by the summit of the bench magma at the central crag, but from about September 18 on there was pronounced revival of gas pressure in the lake magma, some compensation of subsidence of the benches by construction upward of ramparts and a rebuilding of the northwest cone over the wall crack, along with renewed hissing and flaming in other cones.

The measurements were:

September 13—Elevation central crag above southeast rim, 47 feet.

September 19—Elevation central crag above southeast rim, 38 feet.

The crag had thus subsided 9 feet in six days, making an average of downward movement of 1.5 feet per day. The lakes maintained depression of about 50 feet below the rim, and so approximately rose about 10 feet with reference to their shores.

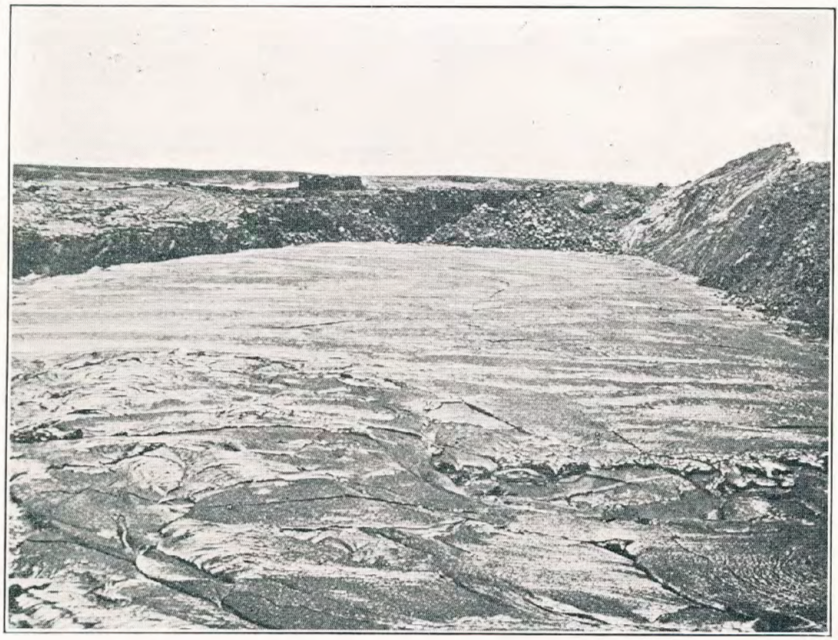
On Saturday, September 14, it was evident that the crags were sinking somewhat faster, the lakes were lower than on the preceding day, and the pit was smoky. The main lake was moderately active, level with its spatter margin, and appeared rising. Streaming was eastward and then the currents forked toward the north and south grottoes, the stream taking its rise at the arch in crust which covered the central pool. There were occasional central fountains in the east arm. The crevasse in the bottom of the east fill appeared somewhat less open. There were slight falls of rock from the eastern outer wall of the pit near the east shelter and from the north crag.

On September 16 the crags tended to

1. August 8, 1918. South valley wall crack laking and filling.

2. August 8, 1918. North crags tipping back and northeast wall valley filling.

Filling of Marginal Valleys, Halemaumau.



3. August 15, 1918. Northeast wall valley nearly full.

4. August 22, 1918. Southwest cone over wall-crack (old edge lower right corner), southwest heap overwhelming edge of pit in background.
—Photos Jaggar.

become more stationary and the glow at night was slight. From 5 to 6 p. m. the lakes showed occasional breaking-up spells with foundering of crusts, the southeast pond was crusted over, and the main lake was bombarding the bank under the northeast grotto, showed border activity at one or two other grottoes, and streamed eastward slowly. The east wall crack and the crevasse in the bottom of the east fill appeared wider. The chasm extending from the southwest pond to the southeast cone depression had now widened into a distinct inner valley which was part of the annular depression surrounding the central group of crags and bounded on the outside by the elongate escarpments which formed the inner revetments of the three great wall-valley fills, respectively northeast, west and south. This southern inner valley had been formed by down-tilting of the back slope of the central crag mass.

During the next two days, September 17 and 18, the crags showed little movement, the fume was moderate with tendency to grow thinner, and the nights showed glowing activity in the center and toward the east and but slight glow from the northern lakes. There were very slight changes in level, but the east fill rose somewhat and the smoke from the southeast cone crevasse was greatly diminished. A striking feature of this time is that it is seismically very quiet.

On Thursday, September 19, however, inspection at 2 p. m. revealed a very marked increase of gas pressure, a widening overflow rim all around the southeast pond, with a spatter grotto building on its west side, and large dome grottoes in process of building south, northeast and north of the main lake. Streaming was eastward, there were continuous noises from the fountains, and the southeast pond experienced sudden sinking spells with rapid recovery which were independent and not in sympathy with those of the main lake.

The gateway west of the northwest crag leading into the north lake enclosure presented an even floor of flows which had poured inward from the wall crack fill of the northwest cone. The writer entered the north lake enclosure through this gate and found the northwest pond to be a heavily crusted circular area with a group of hissing vents, among the tumbled rocks north of the pond, which were overhung by stalactites and building spiracles. The north lake was a small oval active pond with a large fresh spatter dome at its north end and two glowing flaming vents northwest of it which were hissing noisily. On the east bank of the lake there was a vent six inches in diameter which was continuously hissing and spurting liquid lava, forming papery sheets of the melt by a glass-blowing process around its orifice and noisily producing much Pele's hair.

The northwest cone had revived with much loud puffing and coughing. There were glowing spiracle orifices and an entirely new spatter cone some seven feet high had built on the west side of the broken cone; the new heap had an elongate orifice in its summit and its outer surface was covered with solidified trickle flows and splashes.

The west arm pond contained a vent which was blowing very noisily in spasms but could not be seen. Everything indicated strongly renewed gas pressure, and the fumes to leeward from the numerous revived vents were sharply irrespirable with sulphurous acid vapor.

On September 20, 1918, at 6 p. m., the renewed construction on the lake shores had built four high half-dome grottoes on the north side of the main lake toward which all currents streamed. There was little sign of lengthwise streaming. Six fountains were commonly in action at one time, sometimes fountaining could be seen at a grotto under the central crag mass, and occasionally central fountains would form towards the east, flinging stringy melt to great heights. Heavy curtains of stalactites had formed in front of the grottoes. The southeast pond showed glowing overhang on all sides. At night there was bright activity in the center and towards the east, the fume diminished somewhat, but the crags were lower.

In the Whitney Laboratory of Seismology progress has been made in preparing the vertical component seismograph, and the optical teleseism instrument has been completely housed in canvas screens to eliminate the effects of air currents. The instruments are recording continuously and the new routine is being improved and consolidated.

HAWAIIAN VOLCANO OBSERVATORY, Sept. 28, 1918.—During the week ending Friday, September 27, 1918, the lava crags in Halemaumau have continued to subside slowly, but no sudden or pronounced movement of any kind has as yet taken place. Except for increased smoke there is no change in the general appearance of the pit. On one day there was a revival of gas pressure in the northwest cone.

On September 22, 1918, at 11 a. m., the general fume from the pit was thinner, the crags were a little lower, and the lakes were slightly down. The southeast pond stood five feet below its recent level of inner bench and the main lake less. Here there were five puffing and plashing border grottoes with the high half-domes of recent formation somewhat broken down. There was much Pele's hair on the benches and crags, and the central pool of the main lake was all covered over with heavy crust on its north and west sides, only a small cove remaining open on its east side. The lakes appeared about 50 feet down as of late, and mostly crusted over without evidence of current, except that active pools in the crust opposite the spatter grottoes showed the usual streaming into the grottoes. Smoke was thick at the east end, obscuring the view.

The north lake stood two to three feet below its border rampart, the liquid actively fountaining, while a vent west of the pool puffed. There were conspicuous grottoes on its east and south shores, but the north dome had mostly disappeared. The northwest pond remained merely a depression floored with heavy down-slumped crust. The northwest cone was hot and fuming, and the lava inside could be heard bubbling and making a hollow sound. A crack in the fresh driblet lava which had poured from the cone extended westward from it. The surfaces all about were covered with fresh lava splashes. There was nothing new in evidence toward the west or southwest.

On Tuesday, September 24, at 2:10 p. m., a sudden sinking of the southeast pond of about three feet was observed with much bubbling and breaking up of crust. Afterwards the pond slowly recovered and crusted over. Streaming in the main lake was eastward and numerous active grottoes along its banks had built large overhanging shells hung with stalactites, some of these amounting to large half-domes. There were occasional violent spells when noisy traveling fountains developed at a place of conflicting currents from east and from west. The lake was covered with thin wrinkled skins. Much smoke rose from the east cross ledge. Other smoking places were the southeast wall crack, the southeast cone crevasse, the north side of the southeast crag and all along the face of the northeast escarpment. The north lakes appeared unchanged, and a striking evidence of renewed gas pressure was the revival of continuous hissing and flaming vents at the northwest cone, consisting of small spiracles on the summit of the cone. The smoke hole in the middle of the west fill was more pronounced and discolored with bright yellow patches of sulphur and alum.

On September 26 at 12:30 p. m. the lakes stood about five feet below their inner benches, a grotto on the west side of the southeast pond kept up much belching and splashing, and six or more border grottoes in the main lake were steadily active, while the dominant streaming was against the north bank. The crags were slightly lower, but no rocks were heard falling, nor was there as yet any other evidence of motion in the bench magma. The north lake was fountaining and very smoky, and the northwest cone no longer hissed. The west valley smoke heap was seen to stand opposite a crevasse gateway leading through the western dip slope to the inner lake depression. The southwest gateway depression had lowered, and through it violent fountaining could be seen at the tunnel in the north end of that extnsion arm of the southwest pond, which now occupied the site of the west arm. From the south the central and western crag masses appeared distinctly depressed inside of the outer encircling scarp. The general condition of the pit indicated continued stagnation and very slow depression.

On Friday, September 27, 1918, at 9:30 a. m., there was increased evidence of subsidence. The southeast

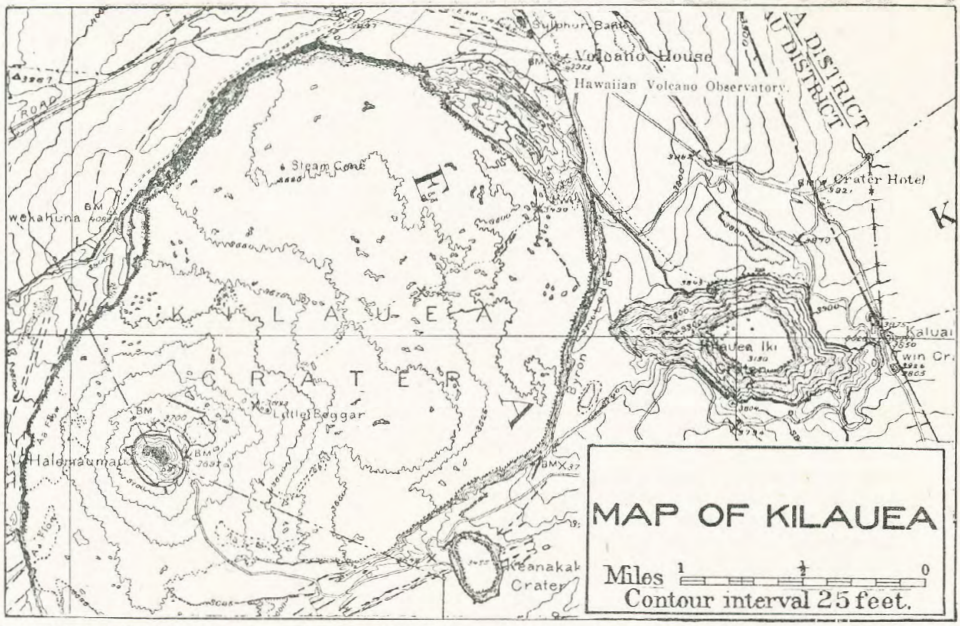
pond was sluggish, standing some 12 feet below its inner bench, and a slide of rocks was heard from the central crag. The main lake stood similarly low within its inner pit and displayed very turbulent fountaining at its southeast cove. There were now five or six long fissures across the south valley from two to three feet wide, and a snapping was heard as though such fissuring was extending itself.

Along the wall margin of the northeast valley fill there was now a wide crevasse extending from the east shelter clear around the northeast quarter of the circumference of the pit all the way to the northwest cone. The north lake was fountaining, but obscured by smoke, and the northwest cone was quiet. The west arm grotto was about four feet high, with noisy and spectacular fountaining. Much smoke rose from the southwest region, and a fall of rocks was heard there. In general, the crags were lower and the smoke more dense.

In the Whitney Laboratory of Seismology the registration of ground movement has indicated a period seismically very quiet. Microseisms have been fairly strong, especially in the north-south directions and that at times of completely calm weather. Microtremor has been ordinary except for some prolonged very quick trembling in spasms September 27. The clinograph exhibited strong diurnal fluctuations, first east, then west, of like amount in each direction until September 24, but thereafter, until September 27, the movement has been a continuous tilt to the west with the daily eastward phase barely perceptible. The tilt change, coming just after the equinox (September 23) was very striking, and the new instrument exhibited it remarkably well.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. All scientific exchanges should be sent to this address.

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN

OF THE

Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, OCTOBER, 1918 No. 10

HAWAIIAN VOLCANO OBSERVATORY, Oct. 5, 1918.—During the week ending Friday, Oct. 4, 1918, the movement of the Kilauea lava column assumed some appearance of definite trend in relation to the recent equinox. It will be remembered that throughout September the general movement was a sluggish subsidence following the very strong rising of August. No second pronounced rising spell preceded Sept. 23, the date when the sun crossed the equator, but immediately after that date there was a very positive moderate increase of subsidence. The curve of lava movement, therefore, was a pre-equinoctial rise of 115 feet from Aug. 4 to Aug. 20, a stagnant month thereafter with slight settling of crags and fluctuations of liquid lava, and beginning Sept. 23, an increase of subsidence, averaging 2.4 feet per day, carried down the large central crag for five days. After Oct. 1 there was recovery, which may or may not continue. If it goes on, the general situation will be much like that of the autumn of 1917, when the equinoctial effect was also very slight. The principal difference lies in the fact that the lava as a whole is this year higher, so that if strong rising follows the coming December solstice, there is a prospect of still stronger overflows at Halemaumau than those of February-March, 1918.

The measures of the past fortnight were:

Sept. 19, elevation central crag above rim, 38 ft.

Sept. 24, elevation central crag above rim, 34 ft.; depression lake, 61 ft.

Sept. 29, elevation central crag above rim, 22 ft.; depression lake, 69 ft.

Oct. 1, elevation central crag above rim, 26 ft.; depression lake, 65 ft.

These figures indicate that Sept. 19-24, five days, the central crag subsided 4 feet, or 0.8 feet per day; Sept. 24-29, five days, central crag subsided 12 feet, or 2.4 feet per day; Sept. 29-Oct. 1, two days, rose 4 feet, 2 feet per day. Similarly the lake Sept. 24-29, five days, sank 8 feet, or 1.6 feet per day; Sept. 29-Oct. 1, two days, rose 4 feet, or 2 feet per day. There was thus a sinking of about 2 feet per day after the equinox, and a rising of like amount after Oct. 1, and this rising still continue (Oct. 5).

On Saturday, Sept. 28, 1918, at 9:30 a. m., a southwest wind and abundant fumes made seeing difficult. The southeast pond was heavily crusted with five-foot inner bench on its margin, and the bench around the main lake was somewhat higher. Activity was sluggish, two border fountains and one central fountain. A small slide took place at the east cross-ledge. A fountain in the southeast pond could be heard pounding and from it low marginal spray was seen rising above the edge of the inner pit for a few minutes. Much fume rose from the southwest heap. No hissing was heard. At 10:30 a. m. the lakes were heavily crusted and somewhat higher. At 9:20 p. m. the southeast pond was quiet but flaming at one side and the main lake was active with a large central fountain in addition to the marginal grottoes. Some rock slides were heard towards the south.

On Sept. 29 at 5 p. m. the inner benches were of about the same height but sharp withdrawal of the lava for several feet was observed in the southeast pond, followed by the usual recovery. Around the main lake and somewhat above the liquid level there were

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large spatter domes covered with Pele's hair, streaming was eastward and there were active grottoes southeast and east as well as along the north bank. A glowing filagree cone stood on the bank of the lake at its northwest corner. A crack parallel to the lake shore followed the high rampart at the east-fill gap. The fountains showed spurting and blowing activity. One of the large cracks in the east fill floor appeared less open. One small rock tumble was heard from under the southeast outer cliff. The north lake was comparatively low, but active, and the active area was enlarged. There was a glowing filagree cone on the north side of the northwest pond depression. There was now pronounced inward slope of the north valley floor towards the semicircle of northern crags, which as a whole had subsided, so that the interior depression was now again in full view.

On Monday, Sept. 30, at 10:30 a. m., the edge of the southeast pond was still about 4 feet high but the main lake stood only 2 feet below the bench. There was the usual activity, and twice cavings in of the bank were observed. Snapping noise was heard from the floor of the northeast valley and rocks slipped a little on the slope of the east ledge. The bank around the north lake was 4 feet high and the northwest cone was quiet. One grotto showed fountaining in the west arm of the southwest pond under a spatter bench only a foot high.

On Oct. 1 at 11 a. m. there was the beginning of marked recovery. At first the margin of the main lake was 4 to 5 feet high, but towards noon the lake rose 2 feet. Streaming was eastward, there were numerous active grottoes and one central fountain, the latter in the east pool, and fumes were so much thinner that at times there was clear seeing to the opposite side of the pit. The north lake was moderately active and sharp hissing was continuous from one of the northern vents. The northwest cone was increasingly broken open and inactive. On descending to the edge of the southwest pond the inner cliff around it was found to be 15 to 20 feet high and the pond itself was mostly sluggish and crusted, with marginal fountains in its west arm and on its southern and eastern banks. At night the glow above Halemaumau was brighter and more extensive than at any time in recent weeks.

On Wednesday, Oct. 2, at 3:45 p. m., the lakes were high and close to the spatter bench level and the marginal fountains puffed from under the crust with the distinctive habit of rising lava. The east fill now showed marked depression as compared with the higher parts of the wall valley on the north and southwest. There was a distinct pressure ridge separating the lower level of the east fill from the higher level of the south valley and extending to the southeast smoke hole from the southeast pond as though a tunnel lay beneath. The lakes were building spatter grottoes. Thick fume rose from the several smoke holes. At 4:15 p. m. the north lake brimmed over and flooded portions of the depression around it; then there came violent fountaining on its northwest margin and rapid sinking of the liquid pool. Hissing was heard from the north central region and near the northwest pond. There was no fresh activity at the northwest cone.

On Oct. 4, at 5 p. m., the main lake stood 4 feet below the new bench of overflow. These overflow floors had greatly widened and built up, the southeast pond was constricted through marginal building out and the new overflow there had nearly passed through the gap leading to the main lake. At the east and northeast coves of the main lake the building up had obliterated the point between the coves. Streaming in the southeast pond was towards its northwest bank where a

grotto rumbled somewhat; in the main lake it was westward. There was much crusted area but the open current was exposed along the north bank and the liquid moved to an active grotto at the west end. The north lake had greatly overflowed the surfaces around it which were still glowing as a wide new floor. An immense dome grotto hung with stalactites stood on the southeast side of the north lake with a flame fluttering above its entrance. A glow heap hissed at the northwest pond site. Between the west crag and the west inner escarpment there was a glowing, flaming and spurting chimney at approximately the site of the west chasm pond. There was no activity at the northwest cone. The southwest pond was fountaining.

The crags appeared lifted and the valleys relatively sunken as though strong new movement in the bench magma had commenced with upward tilting of blocks. The north fill was distinctly lower opposite the northwest gap, and the northwest valley was lower still with a break between it and the surfaces around the northwest cone. The large crevasse east of the northwest cone gaped wider on the pit side and other wall crevasses appeared bigger.

The movements registered in the Whitney Laboratory on the seismographic instruments checked with the volcanic events. Three marked spasms of tremor occurred on Oct. 4. Felt earthquakes have not occurred as yet, but on Sept 30 three small moderately distant earthquakes were registered on the photographic seismograph. Microseisms have been increasingly strong. The clinograph exhibited perfect correspondence by west tilt with the subsidence of the lava Sept. 24 to 29, and by east tilt with the rising lava Sept. 30 to Oct. 3.

Oct. 12, 1918.—During the week ending Friday, Oct. 11, 1918, the rising of the lava column at Halemaumau has continued but with diminished rapidity after Oct. 8. Up to that time the rate of something over 2 feet per day was maintained quite continuously in both crags and lakes. Beginning Oct. 8 the lakes relatively subsided but the crags continued slow rising.

The measurements were as follows:

Oct. 1, elevation central crag above southeast station, 26 feet; depression lake, 65 feet.

Oct. 7, elevation central crag above southeast station, 39 feet; depression lake, 50 feet.

In six days, thus, the central crag rose 13 feet and the lake 15 feet, the former at the rate of 2.1 feet per day and the latter 2.5 feet per day. On Oct 1 the summit of the crag stood 91 feet, and on Oct. 7, 89 feet above the lake surface.

On Oct. 6 at 12:30 p. m. the overflow margin of the southeast pond stood fully 6 feet higher than the corresponding bench around the adjacent main lake, and the pond stood 5 feet below the bench. The lake stood only about 2 feet below the greatly widened floor surrounding the east pool, but in the central region under the high crag and along the north shore of the lake the marginal benches were from 5 to 6 feet high. Apparently the central group of crags had been lifting and carrying with them the central lake margins. There were freshly constructed spatter domes and the fountaining activity was turbulent. At the southeast cone chasm the smoke had greatly diminished.

Streaming in the lake was indefinite in direction, the liquid surface being covered with quiet crusts, which extended to a large cavern at the west end of the lake, brightly luminous within above stagnant glowing liquid. The southeast pond was greatly constricted in area. The north lake was also much constricted to a small round pond at the northern base of the large spatter dome. Its overflow floor, on the other hand, was greatly extended in area. Some hissing could be heard in the northwest pond region, there was no activity at the northwest cone, and some small rock movements indicated motion in the bench magma. The main crags were all higher.

On Monday, Oct. 7, at 5 p. m., the southeast pond was flush with the bench around it and a fountain puffed from under the skin at its north margin. The southwest pond was noisily flinging lava high at the south tunnel corner. Nine fountains were in action around the main lake building a ram-

part which was especially high along the northern and northwestern shore. Streaming was outward from the west end, the current moving diagonally across the lake to the north bank, and there were other currents in bright marginal patches southward to fountains on the south bank. The intermediate area was mostly covered with quiet crusts. The noises were of plashing and puffing, and some rumbling in the grottoes. The widening of the platform at the east end of the lake had diminished the area of the east arm. The southeast pond, however, had enlarged since the previous day. There was much smoke. It should be noticed that the central steeple which is the eastern pinnacle of the central crag mass is again becoming a conspicuous peak standing as an isolated tower.

There was no activity at the northwest cone. Hissing continued in the northern depression. A heavy stalactite curtain had formed across the face of the north lake dome and flame banners blazed above a crack on the top of the dome. About 6 p. m. the curtain collapsed, the pond became active and the flames ceased. On the south side of the western crag mass, above the bridge separating the central pool from the west arm pool, a flaming chimney was spurting lava; another flaming hole could be seen on the west side of the west crag. Under the north station numerous crevasses in the fill along the wall crack were more widely open.

At 6 p. m. Tuesday, Oct. 8, the lakes were low relative to their banks, but the crags were higher. The banks stood 6 to 10 feet high and exhibited stalactite overhang. On the north bank of the main lake one of the spatter domes showed a large glowing chimney 15 feet above the liquid lava. Streaming was eastward, carrying broken up crusts; there were six or eight border fountains and occasionally central fountains migrated to the south grotto, where a fall from the bank was seen. There were deep glowing cavernous recesses at the lake margin on the west, south and northeast, with currents pouring inward at the last two. In the new floor at the east end of the lake a pond of collapse had formed, separated from the lake by the rampart and occupying the former east cove site. Glow could be seen above the southeast pond.

On Oct. 10 at 8 p. m. the lakes were slightly active and there was little change. A glowing chimney had formed above the west side of the southeast pond. Only one conspicuous grotto was seen in activity and that on the north side of the main lake in the middle. The lake had extended itself westward and the streaming was out from the north side of the central pool in a semicircular curve to return against the north bank farther east. There was a glowing and flaming fissure on top of the rampart southeast of the lake. Smoke was rather dense, the southwest and north lakes were glowing, one small rock tinkle was heard and the measured rising of the crag was only slight. There was new glow in some cracks which had extended themselves southward along the bottom of the east fill.

In the Whitney Laboratory of Seismology the only local earthquake registered during the week ending Friday, Oct. 11, was a moderate shock, not noticed here, about 2:25 p. m., Oct. 10. At 4 a. m. on Oct. 11 a teleseism occurred, the preliminary tremor indicating a distance of origin of some 9000 kilometers. This checks satisfactorily with a disastrous earthquake in Porto Rico just reported by the press. Microseisms have greatly increased and volcanic micro-tremors have been as usual. The clinograph showed tilt movement gradually eastward with the strong diurnal variation greatly lessened beginning Oct. 10.

Oct. 19, 1918.—During the week ending Friday, Oct. 18, 1918, the rising of the Halemaumau lava has ceased and the bench magma is practically stationary though the liquid lava has slightly subsided. There have been no marked movements during the week and the general appearance of the pit remains unchanged.

The measurements are:

Oct. 7, elevation central crag above southeast station, 39 feet; depression of lake, 50 feet.

Oct. 15, elevation central crag above southeast station, 37 feet; depression of lake, 58 feet.

Oct. 15, depression below southeast station of inner bench, 46 feet.

In eight days the crag subsided 2 feet and the lake 8 feet; the former at a rate averaging 0.25 feet per day, the latter 1 foot per day. The bench standing 12 feet above the lake represented the maximum stand of the latter about Oct. 8.

There were no essential changes in the pit Oct. 11 and Oct. 12. On Oct. 13, at 4:15 p. m., the main lake was very smoky owing to the development of the smoke holes near the east end. Both it and the southeast pond stood some 10 feet below the inner benches, some border fountains were in action and the crags were stationary. There were no marked changes of any sort. The glow at night was dimmer except for occasional spells of activity in the southwest pond, which brought out the profile of the central crag. The north lake was low within its inner pit. The floor of the east fill appeared a little higher.

On Tuesday, Oct. 15, 1918, at 10 a. m., the lakes continued dull and smoky and from the southeast station the southeast pond appeared 8 feet below its encircling floor and a spurting fountain puffed from under the crust against its north inner wall. In the main lake four or five border fountains were in action, but the direction of streaming was not evident as most of the surface was covered with crust. From the north there was no glow perceptible in the northern lakes. A fresh fall of rocks from the old wall lying on the surface of the north fill east of the north station had evidently broken away very recently. There was no gas pressure in the northwest cone. From the west, turbulent fountaining could be heard in the region of the west arm and the southwest heap appeared more broken down on the pit side. From the south no activity could be seen within the southwest pond. A sulphur-stained patch had developed at the edge of the south valley fill. The crags were stationary and the glow at night dull.

On Oct. 16 from 5 to 6 p. m. there was distinct revival of rising and gas pressure in the liquid lava, six or seven puffing and spraying fountains were in action and the lakes were bordered by marginal floors only 5 feet above the liquid. Flames played through bench cracks both north and south of the southeast pond. The southwest pond was flinging up spray. The main lake was mostly crusted except at the marginal grottoes, the crusts sometimes cracking and foundering, while the border fountains threw up lava spray, constructing spatter ramparts. The north lake was again high and visible, and active on its north and northwest sides. New glow cracks had developed on the south side of the northwest pond depression. A spraying vent was active south of the west crag mass. The crags remained stationary but the lakes were brighter at night.

From 3 to 4 p. m. on Thursday, Oct. 17, the rising activity continued and the fume as seen from a distance was much thinner. There was not much fountaining in the southeast pond but the crack in the bench northeast of it occasionally spurted lava. The banks around the lakes were about 4 feet high and there was much fountaining in the northeast and south coves of the main lake. Noisy fountaining could be heard but not seen in the north lake and the west arm.

On Friday, Oct. 18, at 6 p. m., very active rising of the lake magma was in progress and the crags also started to rise. The southeast pond showed alternations of rapid rising and sudden sinking spells, the rising overflowing the inner floor and the sinking revealing three feet of glow edge and curtains of stalactitic matter. These spells were not shared simultaneously by the main lake, which had its own breaking up spasms followed by loss of gas and subsidence. During one recovery of the southeast pond it overflowed the bench, putting out trickling toes from under a heavy skin, the latter ballooning somewhat and making flame spears through cracks in the skin. On the bench north of the pond spears of flame two feet long shot up from cracks. The streaming in the main lake was eastward in a broad zone and seven or eight fountaining grottoes played almost continuously, some of the fountains against the south bank being very explosive so as to make jets of spray 30 feet high. Flames played through

cracks in the north bank and the lake appeared very large, flush with the bench and building up ramparts. There was also activity in the north and southwest ponds and the glow at night was brighter.

In the Whitney Laboratory of Seismology for the week ending Oct. 18, there were registered moderate local earthquakes at 1:23 p. m. Oct. 13; 3:43 a. m., 7:53 a. m. and 11:16 a. m., Oct. 15; and at 2:57 a. m., Oct. 17. Slight records of teleseisms appeared in the night of Oct. 13-14 and the early afternoon of Oct. 15. Microseismic movement was strong in the early part of the week, diminishing thereafter, and micro-tremors accompanied it, both reaching their maximum Oct. 14-15. The regular sinusoidal tremor has been moderately strong since, but the short-period spasmodic type of micro-tremor, much quicker than the continuous type, and frequently superposed on the latter, reached its maximum Oct. 14, with some paroxysms resembling small earthquakes. These two varieties of micro-tremor, or "volcanic vibrations," are quite distinct from the microseisms.

The clinograph, registering tilt of the ground in the east-west azimuth, (the direction of the line between Mauna Loa and Kilauea), showed eastward tilt with little diurnal fluctuation Oct. 10-13, then began and continued Oct. 14-18 more pronounced diurnal changes with gradual trend west.

Oct. 26, 1918.—During the week ending Friday, Oct. 25, 1918, the lakes and crags of Halemaumau have very slowly risen, the lakes twice as much as the crags. From the point of view of the spectator the condition of the pit has appeared wholly unchanged and the activity has been mostly sluggish.

The measurements were:

Oct. 15, elevation of central crags, 37 feet; depression of main lake, 58 feet.

Oct. 24, elevation of central crag, 40 feet; depression of main lake, 52 feet.

In nine days the central crag thus rose three feet or 0.3 feet per day and the lake six feet or 0.7 feet per day.

On Oct. 20, 1918, at 4:30 p. m., a circuit of the pit by the south and west sides showed the southeast pond to be a circular pit standing 4 feet below its surrounding floor of overflow, with a low rampart above the floor level around its margin and general appearance much like a lunar ring crater. Its annular floor stood slightly above the depression surrounding the southeast cone next adjacent to it through a gap on its southwest side. Moreover the floor stood fully 15 feet above the floor surrounding the main lake. There was a puffing and flaming cone on the floor northeast of the pond, but the pond itself was crusted and quiet.

The main lake was also 4 feet below its rampart, crusted over, and showed little border activity. The only open glowing and streaming melt was in the central pool where the current was so slow as to be indefinite but appeared to move northwestward.

The south valley floor under the south station appeared to be lifting along the wall crack, producing fresh tumbles of rock from the outer wall under the south cone. The same uplift appeared to be going on at the east cross ledge which is now a flattish pile of stones ridged along lines which trend northeast and southwest, the solfatara on the south side following one of the gullies between the ridges.

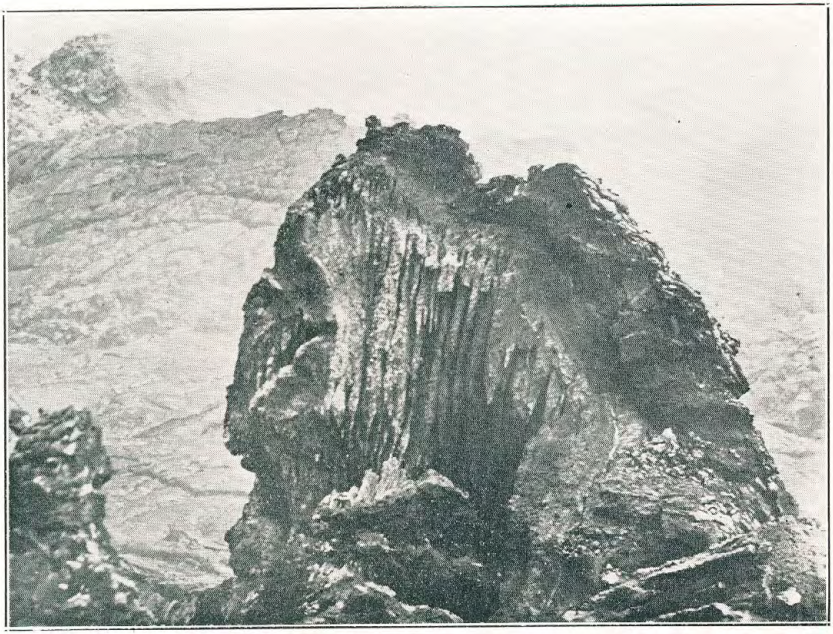
The southwest pond was active and noisy. There was much sulphur stain on top of the escarpment lying next southwest of the western crag mass. The north lake was dull and about 4 feet below its margin. The glow hole of the northwest pond depression was seen to be in the top of a small crag south of the pond. The pit as a whole was smoky and the crags stationary.

On Oct. 21 in the evening the lakes were high and active and the cone northeast of the southeast pond was puffing.

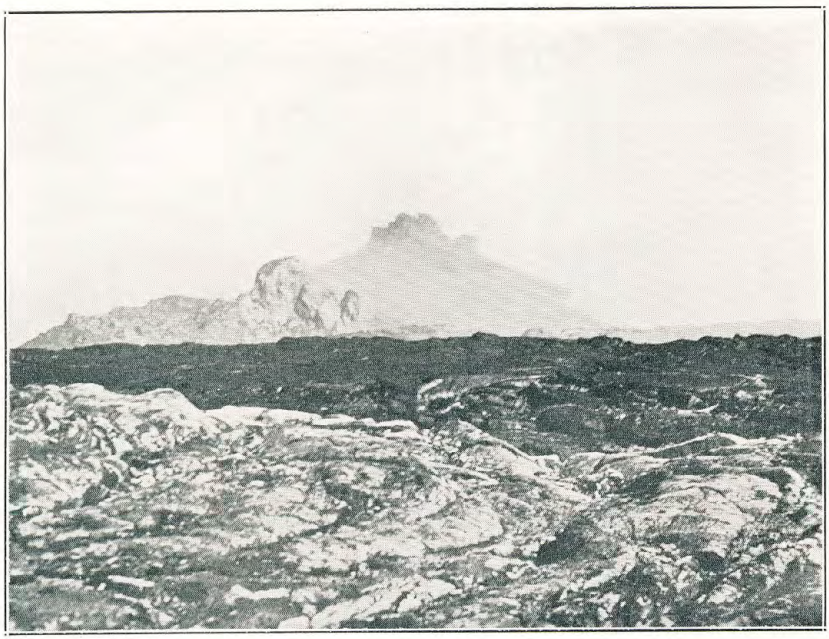
On Tuesday, Oct. 22, 1918, at 8 p. m., this rising activity continued and the lake shores were much built up. The banks around the southeast pond and main lake were about 3 feet high, the fountains were sending up high flings of melt, there was a boiling grotto on the southeast side of the southeast pond and at the cone locality northeast of it the crust had fallen in, leaving an open very bright pot with lava pounding and splashing within. A small

Aug. 22, 1918. New and old north crags formed by tilting back.

Sept. 10, 1918, northwest cone uplifted and broken over wall-crack.
—*Photos. Jaggar.*



Sept. 14, 1918, interior stalactites of northwest cone.



Sept. 1918. Lifted crags, from the west, looking across fresh flows of March, 1918: observer at level of pit rim.

flame chimney flared on the northwest side of the pond.

The main lake was streaming steadily east from the cove in the crust of the central pool. There were numerous fountains on the north and south banks and much breaking up with development of central fountains. Glowing filagree flame cracks had developed on the north and south banks of the lake. Flames played above a grotto on the southeast side. As before the lake stood 10 to 15 feet lower than the southeast pond.

The southwest pond was flinging high spray, the crags continued nearly stationary, the noises were chiefly the plash of fountains, the fume was thinner, and all the lakes showed bright glow at night.

On Oct. 24, at 11 a. m., conditions were more sluggish, the lake margins were 4 to 6 feet high and the pot east of the southeast pond had sealed up except for flaming cracks and there was left a lumpy area and a sulphur stained flattish small cone with central crater. The main lake was streaming eastward and was moderately active along the north bank and both lakes showed the usual alterations between rising and falling. No activity was visible in the north or southwest ponds. The crags were stationary and the fumes moderately dense.

On Friday, Oct. 25, 1918, at 6 p. m., the lakes were sluggish, dark and crusted. About 6:30 p. m. there were breakings up of crust in both the eastern lakes, fountains developed in the southeast pond on the northwest and south sides and in the main lake along the north, south and southeast shores. Streaming in the southeast pond poured under its northwest bank where stringy stalactites dragged in the liquid six feet below the floor above. The zone of streaming in the lake with motion eastward extended from the west end in a curve to the south grotto and a second shorter belt moved from a quiet crust in the east pool to the south grotto. From the opposite sides of the same crust there was inward streaming to the bank at the northeast grotto.

There were flaming filagree chimneys over the south grotto of the main lake and on the south and northwest banks of the southeast pond. The cone on the east side of this pond was flaming through many cracks with steady pulsations of gas pressure. There were fallings in of the banks on the northeast sides of both the central pool and the southeast pond. Some small rock falls were heard. The solfataric patch on the south side of the east cross ledge was seen to be decomposing the rocks and extending itself. The southwest and north ponds exhibited only slight activity. The night glow and general fume were both moderate.

There was registered in the Whitney Laboratory one small local earthquake about 2:30 p. m., Oct. 20; a teleseism in the night of Oct. 18-19; and an indistinct trace of one on the afternoon of Oct. 22. This latter coincides in date with a dispatch from Guatemala reporting a disaster there. Microseisms and micro-tremors of the week have been ordinary. The clinograph registered slow eastward tilt Oct. 18-20, stronger diurnal pulsations about a stationary position Oct. 21-23 and renewed eastward trend Oct. 24-25.

Nov. 2, 1918.—During the week ending Friday, Nov. 1, 1918, the recent rising of the Kilauea lava column increased strongly and somewhat suddenly beginning Oct. 29. Both crags and lakes rose and the rising became very rapid on Friday, Nov. 1. The liquid lava, which has lately lagged somewhat behind the crags in rate of uplift, began after Oct. 30 to rise faster than the crags, and this spurt reached a culmination in the early morning hours of Nov. 2. At that time, after a powerful earthquake shock just before midnight had jolted the whole island of Hawaii, molten lava welled up cracks in the rim rock of Halemaumau pit on the north side, and as much as 170 feet back from the edge, forming craterlets above two vents and sending a flood cascading into the north wall valley of the pit, as well as away from it to the north. Exactly simultaneous with the rise of the lava for four days, the ground at the Observatory tilted sharply to the north and east, and coincidently with the earthquake and lava flood, the ground recovered from this

tilt instantaneously, as shown by the clinograph.

The transit measurements of the rising lava in the pit were as follows:

Oct. 24, elevation central crag above southeast rim, 40 feet; depression main lake, 52 feet.

Oct. 30, elevation central crag above southeast rim, 58 feet; depression main lake, 38 feet.

Nov. 2, elevation central crag above southeast rim, 70 feet; depression main lake, 23 feet.

These measurements imply that for the six days Oct. 24 to 30 the crag rose 18 feet or 3 feet per day, while the lake rose 14 feet or 2.3 feet per day. For the three days Oct. 30-Nov. 2 the crag rose 12 feet or 4 feet per day, while the lake rose 15 feet or 5 feet per day.

This rapid rate of rising recalls the great rise from June to December of 1916, and the spurts of rising later which finally led to the overflow of February, 1918. The present upwelling back of the north rim recalls the similar "artesian" spurt of Feb. 15 last, which was farther east on the same line of crevasses, which extend through the north driblet cones of 1894. The present situation seems to justify further the comparison made with the autumn of 1917 in the Weekly Bulletin of Oct. 5, 1918, when the prospect was pointed out of still stronger overflows.

On Saturday, Oct 26, 1918, from 3 to 4 p. m., a circuit of the pit by east and north revealed only continued sluggishness of the lakes and much crusting of their surfaces. The southeast pond lay 5 feet below its margin and appeared to be rising, covered with heavy skin. There was glow in the cone on its northeast side. At one time the crust broke up with the usual deflation and subsidence of the melt, and then the crust reformed. The main lake when first seen was similarly crusted, but one grotto later became active at the northeast corner of the lake and exhibited blowing and spraying. No activity was visible in the north lake and the smoke was there heaviest. The southwest pond was noisily fountaining. The crags continued to rise slowly and the glow at night was dim. Except for continued rising of the crags no important changes took place Oct. 27.

On Oct. 28 at 3 p. m. a circuit of the pit by way of the south and west sides was instructive because of light southwest wind which made visible places usually obscured by fume. The southeast pond and main lake were fountaining vigorously and a flaming pot northeast of the southeast pond was hung with stalactites. During a spell when the pond sank a foot or more, remarkably deep overhang extending inward at least four feet was revealed around the pond under fully three feet of thickness of platform shown in the bedded vertical wall of the pond's inner pit. Similar overhang appeared around the main lake. The lake was crusted in the center but open glowing melt streamed from a V-shaped edge of crust northeastward in the region of the northeast cove.

From the south station it was evident that the escarpment overhanging the southeast cone depression on its south side had been lifting so as to accentuate the inner annular valley and so as to cut off the view of the southeast pond. The swelling up of the south floor had produced a V-shaped gulch between it and the wall at the base of the south-southwest outer cliff of the pit. The inner valley encircling the central group of crags was very striking as one looked along the west chasm valley, now quite a wide depression extending northward from the southwest pond along the west base of the western crag mass. On its west side this valley was bounded by the infacing escarpment of the uptilted wall valley floor. The same is true on the south and northeast so that the arrangement is quite symmetrical, three elongate craggy ridges in a triangle separated at their ends by three chasms leading to the lakes within the inner depression. Each chasm corresponds to a group of lakes, respectively at the north, at the southwest and at the east.

A heavy fall of bank material was seen to tumble into the western part of the southwest pond, creating great fiery commotion and indicating movement in the bench magma. A grotto was pounding in the west arm extension of the southwest pond.

The northwest cone was sending up hot steamy fume noiselessly. The north lake was noisily fountaining, hidden by its ramparts, and there was hissing from the northwest pond vent. The east fill had now become the lowest place in the wall valley. At 3:30 p. m. the main lake and southeast pond were low with grottoes rumbling.

The sudden spurt in uplift of the bench magma on Tuesday, Oct. 29, brought the glowing chimney of the northwest pond depression into plain view from the Observatory over two miles away.

On Wednesday, Oct. 30, 1918, at 11 a. m. the writer climbed to the summit of the northeast crag mass, then along the crest descending by way of the saddle between the two north crags and explored the north lake depression. The crags had been rising strongly and the slopes were unstable. The lakes had kept pace with the crags, appearing as before about 4 feet below their inner benches. The southeast pond showed the usual alternations between crusted rising spells and tumultuous sinking ones and the main lake occasionally showed fountaining still more violent, with eastward streaming. The pot on the east side of the southeast pond was quiet and covered with Pele's hair. The southeast crags were in motion with rocks sliding. The difference in height between the depressed east fill and the lifted south valley fill was still more marked.

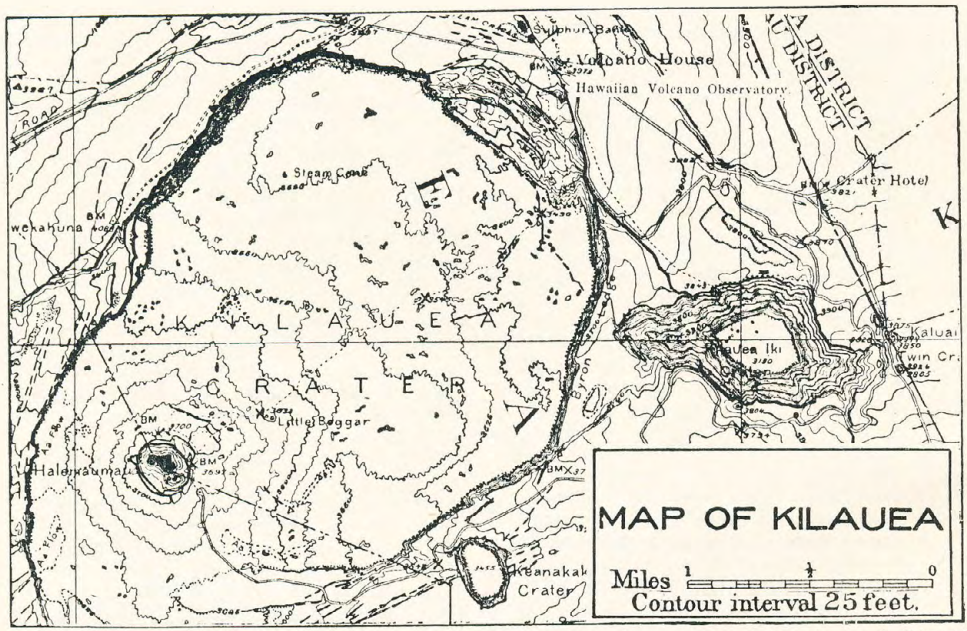
Looking down from the summit of the north crag mass the north lake was seen to be enlarged westward and there overhung by one of the small crags in a cavernous recess. On the western side of this crag, about 20 feet high, there was a glowing, hissing and bubbling lava chimney formed in cracks which possibly communicated with the cavernous recess mentioned. This was the glow spot visible from the Observatory. Another large filagree flaming area had formed among the crusts north of the north lake. The chasm leading northeastward from the north lake depression contained a broken driblet cone not especially fresh. Fume was still abundant and the glow at night mostly dull.

On Oct. 31 in the evening, with increased lift of the crags the lakes were also higher and were fountaining strongly. The rising continued on Nov. 1 with nothing especially novel until the great crisis of earthquake and lava outburst, mentioned in the introductory paragraph and to be more fully described in the next week's report.

In the Whitney Laboratory of Seismology a teleseism was registered about 7 a. m. Oct. 27. The first and second phases were not perfectly exhibited but the evidence pointed to an origin about 5700 kilometers away, the distance of Kamchatka, Mexico, or the New Hebrides. On Oct. 31 a local tremor occurred at 9:14 a. m. and a small quake about 3:07 p. m. Microseisms and micro-tremors have been ordinary with some increase in the former. The clinograph showed moderate daily tilt fluctuations Oct. 26-28, but this changed Oct. 28-Nov. 1 to great increase of the eastward tilt over the westward so as to net a strong eastward movement. The other instruments showed at the same time very strong north tilt indicating that the actual direction of tilting was northeasterly.

Very respectfully,

T. A. JAGGAR, JR.
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. All scientific exchanges should be sent to this address.

In 1917 there are about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly reports since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The weekly bulletin as it appears in the Honolulu Advertiser is reprinted as a leaflet and sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund of geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with two Bosch-Omori 100 kg tromometers registering N-S and E-W motion, a heavy Omori tromometer registering E-W motion, and an Omori "ordinary Seismograph" designed for registering strong earthquakes in all three components of motion. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, NOVEMBER, 1918 No. 11

WEEKLY BULLETIN OF HAWAIIAN VOLCANO OBSERVATORY.

HAWAIIAN VOLCANO OBSERVATORY, Nov. 9, 1918.—The week ending Nov. 8, 1918, has been eventful as one of the times of much volcanic activity, rising lava and seismical trembling, following upon the pronounced earthquake of Nov. 1. The lava crags have continued to rise and tilt back, more slowly than at the time of the crisis, and the liquid lava, which spurted up from new vents on Nov. 2, has flowed and built heapings on three sides of the pit and considerably filled portions of the wall valleys. The end of the week finds the lakes only a few feet below the rim of the pit, the highest crag some 80 feet above the rim and at the moment the rising has ceased. In addition to the pronounced earthquake of Nov. 1 there was a sharp shock, felt strongly in Hilo as well as here, on Nov. 7 and a powerful distant earthquake was registered in the evening of the same day.

The measurements at the pit were as follows:

Nov. 2, elevation central crag above southeast rim, 70 feet; depression of main lake, 23 feet.

Nov. 5, elevation central crag above southeast rim, 76 feet; depression of main lake, about 17 feet; depression of southeast pond rim, 13 feet.

The lakes and crags thus rose for three days after Nov. 2 about two feet per day, slowing up thereafter until Nov. 8, when they became stationary.

Press reports indicate that the earthquake of 11:33 p. m. Nov. 1 was most strongly felt at Kapapala Ranch on the southeast flank of Mauna Loa 15 miles southwest of this station. There some damage was done to such objects as water tanks and stone walls. The first two shocks at Hilea are reported as lasting three minutes and throwing down some objects such as small bottles. Mrs. de la Nux there reports the first shock at 11:36 p. m. and three others at 11:38, 11:46 and 12 midnight. Another pronounced shock was felt at 5:01 a. m. Kona and Hilo both reported strong shocks without damage and apparently somewhat stronger effects were noted on the north flank of Mauna Kea in the line of the Mauna Loa-Mauna Kea axis. At Kilauea the earthquake was prolonged with strong east-west rocking, and numerous avalanches were started from the cliffs. The very intense initial motion lasted for about a minute. All phases of the movement were registered on different instruments in the Whitney Laboratory. Like the earthquake of June 14, 1918, this shock kept the ground in vibration as recorded seismometrically for over 40 minutes. There were recurrent intense spasms during this period and three small earthquakes during the after midnight hours. The weather was still and foggy at the time of the earthquake, strong northeast wind springing up after it. The whole occurrence strongly resembled the night shock of Oct. 25, 1913.

During some time in the early morning hours of Saturday, Nov. 2, 1918, the east-west cracks on the north sides respectively of the old stone rest house ruin and of the government bench mark set in a concrete table, on the north brink of Halemaumau, opened and emitted liquid lava. At 11 a. m. cone vents in the midst of fresh flows were here spouting like artesian wells. The flood invaded the horse corral on its west side and poured from the northern-

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Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

most vent over 100 yards in a northwesterly direction. From the rest house vent the lava cascaded over the edge of the crater into the north wall valley of the pit on both sides of the new concrete post at the north station. The old rest house was nearly completely buried. The bench mark at the site of the former Technology Station was spattered but not injured. Heavy doming fountains of melt were bubbling at the two pots, and the solidified material was the usual glistening black pahoehoe. A little farther west the 1918 lava at the edge of the pit adjacent to the northwest cone had been uplifted 5 or 6 feet. All the sudden changes of this night were confined to the north rim.

The main lake was surrounded by uplifted banks 5 feet high and showed the usual eastward streaming, foundering crusts and active border fountains. The southeast pond was flush with its margin and the vent east of it was hissing and glowing. The north lake was fountaining at its northeast end and fresh lava occupied the floor of the northwest pond depression The southwest pond was fountaining and the escarpment south of it appeared strongly lifted at its eastern end. There was also uplift at the southwest lava heap and the crags were all rising

At 10 p. m. the night view showed plainly in the lakes the characteristics of rising activity—in the brimming lava of the southeast pond, the flaming chimneys and splashing pots, and the noiseless steady bright fountaining activity of the main lake with slow eastward streaming in straight brilliant lines. The north lake was the same and the cliff chimneys west of it and the filagree cone north of it were very brilliant. The north fill was luminous with fresh lava in motion. The vents had become flaming and hissing cones, the northern one 5 feet high. Glow could be seen in the west crag chasm.

Inspection of the Kilauea walls showed fresh earthquakes debris at two places along the Uwekahuna bluff on the west side, at the north cliff, and on the east side of Keanakakoi crater.

On Nov. 3 at 5:30 p. m. the lakes continued very brilliant and rising. The southeast pond was spraying, with blowing at the cone and flaring at the chimney west of the pond. The main lake was streaming eastward and the grottoes were heavily curtained and splashing. The southwest pond was brimming full and spraying high. The north lake was flinging up strings of melt and the other vents flaming.

The new flows had spread and greatly thickened about the rest house vent nearest the edge of the pit, this becoming the main source. The station post was now enveloped in lava. At the top of the heap a filagree flame cone stood fully 15 feet above the site of the old rest house. The fresh lava was hard enough to cross along the cascade line at the edge of the pit. Lava toes were making out sluggishly and the bottom of the north fill was much built up. At some time after 7 p. m. the southeast pond overflowed for over an hour, flooding the east wall valley all the way from the south station to the northeast valley and making a magnificent display with cracking and foundering of the new pool. The fountains could be seen from the Observatory.

On Nov. 5 at 11 a. m. the new east fill had contracted and slumped, but its surface was only about 30 feet below the rim of the pit. The solidified cascade from the southeast pond was about 15 feet wide. The main lake had not overflowed, the banks lifting with the crags and showing many cracks and a mat of Pele's hair. A high rounded driblet cone was level with the bank at the south grotto, but the lake stood 7 feet below the bank level. The cone east of the southeast pond continued flaming and hissing and burning gases continued to rise from the chimney west of the pond. The pond platform of overflow continued to stand at a level well above the floor level of the main lake and considerably above the valley depression of the old southeast driblet cone leading off to the south-

west. All of the lakes were now so high that their ramparts cut off the view of the active portion most of the time.

The southeast pond and the main lake rapidly rose during the morning so that the former at 1:30 p. m. was visible from the southeast edge of the pit 3 feet below its platform and later it overflowed slightly.

Large lava heaps had now been built above the wall crack on the north and southwest sides of the pit and opposite the gateways which there, as at the east, lead inward through the crag walls to the interior lake depressions. These heapings stood above the level of the rim of the pit, both through overflow and uplift section, and from both of them flows had poured right and left along the wall valley. The source of these flows at the southwest heap was a group of hissing cones; and the strong uplift had overturned the bronzy driblet cone of August.

At the north heap flows were pushing across the surface and the rim of the pit for 200 feet was now buried to a depth of from 5 to 15 feet beneath the pile of lava poured from the old rest house vent. The flows from the northern vent had been swelling into domes. The symmetry of the three sources of overflow north, southeast, and southwest, opposite the gaps in the triangle of crags, is very striking.

The bodily uplift of the bench magma was now becoming pronounced in its effect on the flat marginal portions of the valley fills. The south valley crust was rising to become a crag, the southwest heap of August, and the northwest cone were now uplifted 10 feet over the rim of the pit, and all the crag slopes gave evidence of motion in occasional slght tumbling and rolling of rocks.

On Nov. 6 at 3 p. m. the fresh short overflows of the southeast pond were seen to terminate in elongate toes following the course of the previous cascade. The inner pit of the pond had 12-foot walls over the glowing melt with considerable overhang. The adjacent cone was hissing and flaming. Examination of the edge of the main lake showed the liquid there also to be 11 feet down, the banks east and south consisting of fissured oldish shells covered with Pele's hair. A glow hole emitted sulphurous fumes on the south side of the eastern gateway and similar fume rose from the east cross ledge. There were several high and heavily curtained grottoes, the lake streamed slowly eastward, covered with heavy folding skins and an island in the west central region about five feet high showed a row of jagged points with surfaces tipping northward.

There was now a tumbled northeast valley or chasm, a crag west of this and a slope of talus leading down to the northeast cove. The east ledge overhung a low bench at the lake shore. The central pool was bounded by cliffs on the north and south sides and a flatter floor west. Beyond, on the east and south sides of the west crag mass, were masses of choked and uplifted material.

The north lake depression showed flaming and hissing vents north, west and at the middle crag chimney, and fountaining could be heard in the lake amid much smoke

The active north rim cone was emitting a sluggish flow a few feet toward the west but otherwise the heap was stagnant As a result of uplift beneath, the northwest cone was breaking to pieces.

The crags continued to rise and the lift of the southern floor was making a strong escarpment on the west side of the southern crevasse. Glow in the evening was not bright but fountains of the southeast pond could be seen from the Observatory.

On Thursday, Nov. 7, 1918, at 5 p. m., a circuit of the pit by south and west revealed a most striking change, greatly increased upward swelling opposite the three gateways north, southwest and southeast. There was a sharp earthquake at noon followed in the afternoon by driblet flowing on the north with numerous lobes pushing out in the northeast valley. At the southeast the lakes were from 3 to 5 feet below their banks, the streaming was east, the lake surface glowed with bright lines, there were numerous fountains and grottoes and large flames played above the cracks in the cone at the southeast pond. The island seen yesterday in the main lake was now joined to the north bank. The south floor changing into a crag was now so much uplifted as to cut off from the southeast station the view of the southwest rim of the pit.

The uplift effects were repeating the

tumescence of February-March last. The southwest heap had lifted so much as to push up the old edge of the pit. The great general uplift of the west crag mass was tilting back the west floor. The uplift at the northwest cone had jammed the old rim of the pit backward so as to swell it into a half-dome. As result of this the wall crevasse showed increased gaping.

In the southwest pond there was activity at the moment only in the northwest end, but a large new spatter dome showed above the inner cliff at the southwest side of the pond. The north lake was spraying high against its north bank and the adjacent crag chimney was flaming. The north rim vent was hot and flaming and the fresh flows were swollen everywhere into domes glowing through the cracks, while moving flows sluggishly trickled in the northeast valley.

On Nov. 8 in the morning the activity was dull, the inner cliffs 6 feet or more high and the rising of the crags diminished so that the next day they were practically stationary.

During the week from 8 p. m. Friday, Nov. 1, to 8 p. m. Friday, Nov. 8, the seismographs of the Whitney Laboratory have registered one strong local shock and a succession of weak and slight ones. This followed a period of two months of seismic quiet. The strong shock occurred at 11:33 p. m. Nov. 1 with a first movement west-northwest, the direction of Mokuaweoweo. The seismic swaying of the ground in waves of long period continued until 12:26 a. m. Nov. 2, fifty-three minutes. There were recurrent quick-period shocks at 11:44, 11:52 and 12:07 superposed upon the long waves. Other shocks Nov. 2 were at 2:18 a. m., 3:01 a. m., 5 a. m. and 6:30 p. m., and two feeble shocks. Nov. 3 there were two weak shocks; Nov. 4 two feeble spasms of trembling; Nov. 5 one very feeble spasm; Nov. 6 one spasm; Nov. 7 a sharp felt shock at 12:05 p. m., two weak shocks in the afternoon, and two feeble spasms near midnight; Nov. 8 no earthquake.

A powerful teleseism Nov. 7, at 6:19 p. m., Hawaiian time, gave evidence of origin 5600 kilometers away in a direction probably either north-northwest or south-southeast. This earthquake greatly resembled the shock which gave rise to the tidal wave of Sept. 7. The origin may have been either in Kamchatka or under the South Pacific Ocean.

The microseisms and micro-tremors of the week have been ordinary. The clinograph pendulum was jolted west by the strong earthquake of Nov. 1 and remained in the offset position as though the ground had suddenly been restored from its position of eastward tilt accumulated during the previous week. From Nov. 2 to Nov. 8 the daily fluctuations of tilting have been rhythmic with slow eastward tendency.

HAWAIIAN VOLCANO OBSERVATORY, Nov. 16, 1918.—History has repeated itself at Kilauea volcano during the week ending Friday, Nov. 15, 1918, in that, after considerable flows on the floor of the greater crater, another gigantic subsidence of the lava column has taken place in a fashion which up to the present almost duplicates the events of March 26 to April 1 last. The great cylinder of stiff lava surmounted by rocky hills, yawning chasms and lava pools has sunk bodily 200 feet while the liquid lava in its midst has relatively risen and overflowed its banks. The only topographic features of the interior of Halemaumau pit disturbed by the subsidence are the marginal portions of the inner surface, broken and piled with debris from the disrupted cliffs. There is left the familiar fire pit over 200 feet deep, with bubbling lava pools amid inner craggy ridges, one of which still stands over 90 feet above the liquid. During the maximum downward movement there have been many avalanches and small earthquakes, but the fume from the pit has thinned so as to be inconspicuous and the comparatively frictionless fluent character of the movement has been its most remarkable trait. The conviction, to the writer's thinking, that the main lava column is a stiff fluid surmounted by the great crags and floors as a rifted crust, is inescapable after inspection of one of these subsidences. The liquid fills the rifts for very limited depths and wells up when the blocks are squeezed in the narrowing funnel of the true crater.

An event of no small importance on Nov. 10 and 11, dwarfed by what followed, was the voluminous outpouring of more lava flows from new vents of the north rim locality so as to send two elongate serpents of pahoehoe far across

the western fields towards Uwekahuna, making an aggregate length of new flows comparable with the overflows of last February, but on the opposite side of the pit.

The measurements of the week exhibit the following remarkable changes:

Nov. 5, elevation central crag above rim, 76 feet; depression of lava lake, 17 feet.

Nov. 13, elevation central crag above rim, 69 feet; depression of lava lake, 33 feet.

Nov. 14, elevation central crag above rim, 17 feet; depression of lava lake, 72 feet.

Nov. 15, depression central crag below rim, 32 feet; depression of lava lake, 112 feet.

Nov. 16, depression central crag below rim, 142 feet; depression lava lake, 239 feet.

These figures indicate that:

Nov. 5-13, central crag sank 7 feet in 8 days, or 0.9 feet per day; lake sank 16 feet, or 2 feet per day.

Nov. 13-16, central crag sank 211 feet in 3 days, or 70 feet per day; lake sank 206 feet or 68 feet per day.

During the first of these three days the central crag sank 52 feet, the second day 49 feet and the third 110 feet.

On Saturday, Nov. 9, conditions were sluggish in the pit, crags nearly stationary, lakes low and the new cone on the north rim of the pit was hissing and building driblet spiracles which showed yellow sulphurous deposits. The concrete post of the north station was now completely surrounded by heavy flows. Glowing toes of fluid pahoehoe were in motion in the northeast valley at one place only. The tumescence had been extended to the wall*valley floors, for the wall crack along the northeast margin of the northeast valley was closing together all along the rim of the pit; within two days three to five feet of gaping had closed to less than a foot. Other evidence of upward swelling was shown by the backward tilt away from the center of the pit of the fresh flows of Nov. 3 at the east end of the northeast valley floor. Furthermore the east cross ledge had been upset eastward so that bowlders had rolled down on the fresh east valley fill leaving tracks. One three-ton bowlder lay ten feet out opposite the east gateway.

A heavy rain storm for the next three days made inspection difficult. On Nov. 10 at 6: 30 p. m. the north rim vents were spurting in spasms and at this time strong revival of westward flowing started.

On Monday, Nov. 11, at 5:30 p. m., a circuit of the pit by the south and west rim revealed from the view-point of the 1894 rampart at the west niche a long glowing lava flow between there and the west wall of Kilauea crater, pushing its front southwestward. The writer crossed to its front and followed its whole length, finding its source at two new flaming and hissing cones 80 feet west of the cone at the north horse corral. From that point the course keeps parallel to the edge of Halemaumau and 200 feet back of the edge and then strikes off across the 1894 flows which are partly aa. This flow was 1500 feet long, of width varying from 30 to 80 feet. The lava is the usual black lumpy pahoehoe. The cones at the source were ten or more feet in diameter with filagree crests and small flames. The cone at the corral glowed, but slightly. The north station cones were very bright with recent swelling and fresh flows from them had piled up level with the south wall of the corral and had penetrated the corral entrance at its east end. The bench mark monument is uninjured.

The crags and floors were still more swollen, glow was conspicuous under the floor of the east fill, flames were abundant at the southeast pond cone, in cracks at the east gate and above the south grotto. The lakes stood four feet below their margins with fountains flinging visibly and there were sounds of strong activity in all the lakes. Glow could be seen in the west chasm and the inner crag vent of the north depression flared brightly. The rim of the pit at the northwest cone and southwest heap localities was now pushed up in ridges 20 feet high. The western scarp crag was lifted and the loom of all the crags suggested high pressure, agreeing with the evidence of the abundant burning gas and strong lava flow.

On the evening of Nov. 12 at 8 p. m. new fronts of the western lava flows were plainly visible in motion farther to the northwest than the first flow seen.

On Nov. 13 at 10:30 a. m. an exam-

ination of the flow locality showed the north rim cones to be inactive and the fresh flows hot but not in motion. The longer western flow was unchanged, but a second arm starting from the cone source had poured 400 yards northwest. This was the flow visible from the Observatory.

On this day the crags had begun subsidence and there was slight sliding of talus. The eastern lakes stood 5 to 8 feet below their banks, the main lake crusted and stagnant except for eastward streaming pools against the east and north banks, into the south grotto and at the west end. At the north and west there was spatter constructing and the liquid appeared rising. The east covebank had caved in, enlarging the cove. The southeast pond also appeared rising, its crusts being quiet except for fountains against the northeast bank and a collapse seen at the northwest shore. The cone east of the pond was sulphur stained and flaming. The north lake had been overflowing and extending itself voluminously so that with its overflows it had now a horseshoe shape extending around the north side of the crag west of it into the northwest pond depression. There was a fresh spatter heap at the western flame vent locality. In the evening at 11 p. m. the crags stood very high, and all the lakes were moderately bright.

In the early morning of Thursday, Nov. 14, 1918, there was an earthquake felt generally and rapid subsidence of the lava column began. At 10 a. m. everything in Halemaumau had gone down about 50 feet, the sinking was continuing very gradually, and the lakes were rising relatively to the bench magma and flooding their margins. On all sides, at the base of the outer wall of the pit, an annular zone of the wall-valley floor about 30 feet wide sloped inward at angle of 30° to 40°. The steepest of these slopes east and northeast had wide gaping crevasses at the top. Avalanches were very small but incessant. The fume had thinned. A wide platform of fresh overflows from the main lake covered the central region, and the lake was still building fresh black glistening spatter margins. The U-shaped pool of the north lake had overflowed the northwest pond depression. There were fresh flows from cracks on the wall valley floor northwest. In the northern arm of the southwest pond continuous fountains played against the base of the central crag mass. The southeast pond was brimming.

Shelves clung to the edge of the pit on all sides and the recently upheaved edges north-northwest and southwest had settled back with much cracking. There were wide wall cracks all around but the interior topography of the lava column kept its integrity. The gentlest inward slope was at the south floor. Flat areas of floor remained in the west and northeast wall valleys.

On Friday, Nov. 15, at 11:30 a. m., the column had sunk 50 feet more, but a much more rapid fall took place during the next twenty-four hours, with some spectacular red-hot avalanches at night. The subsidence continued very evenly, with continuous small avalanches, extraordinarily thin fumes, thin-shelf veneers at the recent high level mark, a cliff below 40 to 50 feet high, then the inward sloping steep ring of floor matter tending to lose its flat surfaces and break up into a talus. This outer ring slope was uniform east, north and west, but the southern floor sloped inward more gradually with some breaking down in steps. The northeast valley appeared to be the lowest depression. The southeast and southwest ponds occupied depressions 20 feet deep but were building black overflow margins as were the other lakes. Fountaining in the lakes was in progress at numerous crescent niches. The main lake at 11 a. m. had a short, violent and noisy sinking spell of four or five feet of lowering, with breaking up of crusts and a seething of multiple fountains, and similar milder spells of the same sort happened from time to time in the other ponds. Quiet crusting followed very quickly with complete recovery to the brimming level in a few minutes. The platform and cone adjacent to the southeast pond had collapsed and the pond was enlarged to a squarish shape. Streaming in the southwest pond was northward to the perpetual fountain but elsewhere streaming was indefinite. Fountains in the main lake were against the northeast and south banks and in the north lake high spatter banks were building on both the north and south

sides. A small pot, with rim much higher than the north lake, fountained continuously at the northwest pond locality. The cascade locality of the new flows at the north station retained a wide overhanging shelf of fresh lava. The northwest cone had fallen and new cracks yawned in the old rim at that locality and near the old north station. Small quakes were felt on the edge of the pit, and several at the Observatory were felt during the night of Nov. 15-16 while the subsidence movement was at its maximum.

During the week ending at 8 p. m. Friday, Nov. 15, 1918, the seismographs of the Whitney Laboratory registered eighteen local shocks as follows: One small shock morning Nov. 9, and two in the night Nov. 11-12; two felt shocks in early morning Nov. 13; one felt shock in the early morning Nov. 14; two small tremors night Nov. 14-15, and ten shocks increasing in perceptibility during the day and early evening Nov. 15. Microseisms have been moderate during the week and volcanic microtremors increased Nov. 15. The tilt of the ground, shown by the east-west clinograph, was slowly eastward Nov. 9 to 13, with but slight daily fluctuation, changing Nov. 14-15 to the west, with strong diurnal movement steeply west and more gently east. The seismographs have indicated strong north tilt since the sudden spurt and earthquake of Nov. 1, and this north tilt became excessive at the time of the subsidence Nov. 14.

HAWAIIAN VOLCANO OBSERVATORY, Nov. 23, 1918.—The week ending Friday, Nov. 22, 1918, was distinguished at Halemaumau by the maximum stage of the marked subsidence reported last week, followed by recovery of the lava column. Great numbers of local earthquakes and tremblings accompanied the sinking of the lava, the earthquake frequency varying directly with the speed of the downward movement, and the seismic activity ceasing when the sinking stopped. A great quantity of liquid lava was evolved simultaneously with the downgoing of the bench magma along with almost complete disappearance of fumes. When the crags began to rise the smoke reappeared.

The measurements were as follows:

Nov. 16, depression central crag summit, 142 feet; main lake, 239 feet.

Nov. 18, depression central crag summit, 156 feet; main lake, 220 feet.

Nov. 20, depression central crag summit, 152 feet; main lake, 226 feet.

Other measurements Nov. 20 gave the following: Depression summit north crag, 157 feet; of summit west crag, 183 feet; of north lake flows 209 feet and southeast pond flows 219 feet.

There was thus a rise of the liquid lava Nov. 17-18, two days, of 19 feet, and depression of the central crag of 14 feet; equivalent to an actual displacement of the liquid of 33 feet. During the next two days Nov. 19-20 the lake sank 6 feet and the crag rose 4 feet, making the relative movement downward of lake magma to bench magma 10 feet. The net effects relative to a fixed station on the rim of Halemaumau were:

Nov. 17-20, 4 days, central crag subsided 10 feet, or 2.5 feet per day.

Nov. 17-20, 4 days, lake rose 13 feet, or 3.25 feet per day.

The central crag on Nov. 20 stood above the lake 74 feet, the north crag 69 feet, and the west crag 43 feet. The slope of the newly flooded floor area was downward 10 feet from the north lake depression to the southeast pond area, the former being a conduit area and the latter a sinkhole. The main lake or east pool lay in an inner pit depressed 10 feet below this floor. Just as in April, 1918, the transition from sinking to rising starts by liquid lava flooding and partial drowning of the crags. Then the crags and floors begin to swell up and smoke holes increase in number.

On Saturday, Nov. 16, 1918, at noon, there were incessant rock slides in the pit and occasional fairly heavy avalanches, making much dust. The flooded floors were increasing in size, especially in the central part of the pit. The active lakes were building spatter domes, the fountains being vigorous at the north lake, main lake, southeast pond, southwest pond and west arm pond. Occasional spells of breaking up would occur along with the development of central fountains and subsidence of the liquid surfaces, but most of the time the lakes remained crusted and showed little definite streaming. In the

central region north of the central crag there was a small round pond in a crust of fresh flows. The northern shelf of fresh lava had fallen from the edge of the pit, there was still a large overhanging block clinging at the east and heavy falls were in progress at the southwest. The general condition suggested a lava column becoming stationary with free gas reactions, much heat generating liquid lava and the marginal talus approaching adjustment.

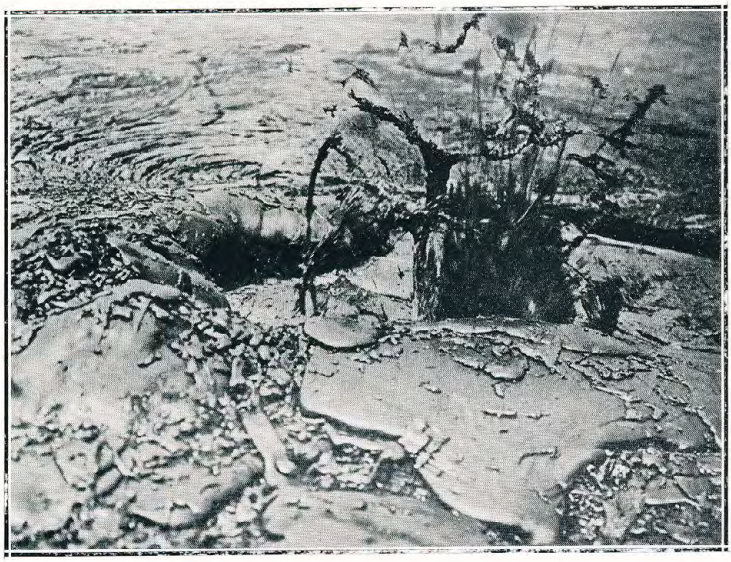
This was confirmed next day, and on Nov. 18 at 3 p. m., the crags were stationary and the lakes rising and flooding the whole central area. A steady continuous fountain bubbled up at the northwest pond locality. The general effect was like a manufacturing plant with furnaces in full blast, ten fountains could be counted and at the spatter domes and crescent niches there was much blowing and splashing and the fume was very thin. A rhythmic fountain burst about every 40 seconds at the west arm and a festooned flow poured thence northward along the gulch between the west crag mass and the western valley escarpment. The whole central area was a vast pooled flow occasionally showing cracking and foundering crusts. Large quantities of Pele's hair were rising from the pit, there were puffing cones on the north side of the north lake and the southwest side of the southeast pond, two active spatter heaps occupied the south side of the southwest pond and others indicated approximate shorelines of the main lake north, south, east and west. Excepting the southeast and southwest ponds, the lake boundaries were indistinguishably merged in overflow. The west and northeast valley floors were now mostly covered with talus. The south floor remained a bench sloping gently inward in a semicircle and east of it there was a slope composed of very large blocks. Remnant shelves of fresh lava clung to the high edge northeast and south.

The spread of the new flows on the floor tended to submerge the smaller interior crags and the western crag mass as well as the west valley escarpment. The central and northeastern crag masses remained high. The former east fill, east cross ledge and southeast pinnacles were now completely buried under talus and this region had probably sunken most. The border ring of uptilted floor material had crumbled to talus except at the base of the south-southeast and northwest cliffs. The southwestern cliff showed a burnt-looking blackish wall with vertical scrapings. The central steeple had split into two pinnacles. The profile of the edge of the pit showed new humps southwest and north made by the recent flow heapings at those places.

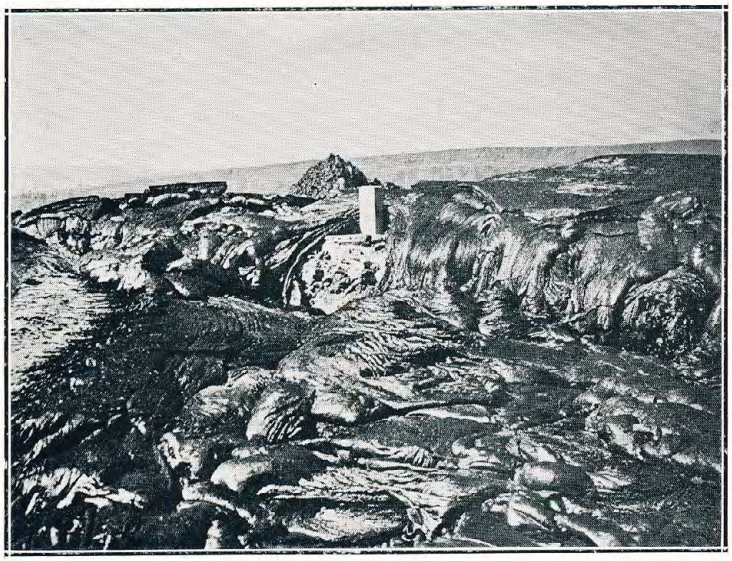
On Wednesday, Nov. 20, at 11 a. m., the detail of the new pit could be seen very clearly, though the smoke vents were increasing in number, especially north of the central region. The main lake had become a small kidney shaped pond at the locality of its east pool, the liquid standing 10 feet below its margin, streaming eastward, splashing in overhanging grottoes, hung with stalactites, north, south and east. The southeast pond had become converted into a flat cone with the tracery of radial flows on its surface and at its summit was a five-foot open pot leading into a brightly glowing interior. A smaller driblet cone stood at the southwest base of the larger heap. There was no trace of the pond outline and fresh flows from these cones covered the flat on their west side out as far as the base of the steeper portions of the central crag mass. The old southeast cone was still in place on the south side of this area. Other fresh overflows extended southeast from the main lake and through them only a small remnant of the southeast pinnacle projected. The north lake had become a small pot about 5 feet deep, showing liquid lava, surmounted on its north edge by a large half-dome. The northwest pond cone was now a small spatter heap and from it an elongate pool of flow lava extended southward to the base of the west crag, its crust occasionally cracking up and revealing the glowing melt beneath. The west arm pond was another small oval pit and the rhythmic fountain beneath a large spatter heap on its east side occasionally exploded. The southwest pond had become a small circular pit with margins 8 feet high.

There were frequent sinking spells in the lakes accompanied by a good deal of turbulence and at such times there was avalanching from the high walls. The west valley floor had been flooded

NEW NORTH FLOWS



Nov. 2, 1918. The fountain pot at the north corral, source of the northwest flows, 11 a. m.



Nov. 5, 1918, 11 a. m. The north station nearly overwhelmed

Nov. 2, 1918, 11 a. m. Remains of old north wall (left) and new north trig. station. Lava cascades pouring into pit.

Nov. 13, 1918, 11 a. m. North corral and government bench mark across new flows. North crag on right. Cones shown were the flow sources.

across the middle saddle of its escarpment by fresh flows which cracked up and showed liquid beneath. The general condition indicated that the stiffer lava column was beginning to rise and produce condensation chambers in the tunnels and wells beneath the floor.

On Friday, Nov 22, at 11:30 a. m., the floor was found uniformly raised by veneers of fresh lava flow all over the bottom of the pit excepting the northeast valley. The western escarpment was more submerged in its middle portions so that only small remnants stood up under the west station and at the northwest crag. The flows from the southeast and southwest ponds had increased so that the old southeast cone was now surrounded by new lava. The open pot at the southeast pond was closed, but there was slight glow in cracks southwest of it. The main lake and southwest pond were pits still smaller than before with walls 10 feet high. In the former there was fountaining in grottoes hung with stalactites north and northeast. A slightly broken down pond depression had again appeared at the base of the central crag on its north side, and a new cone had formed on the central floor near the eastern base of the west crag mass. The latter was now completely surrounded by fresh flows and appeared like a narrow elongate island with the old knob rising from its middle. The promontory of small crags which had formed an extension of the northeast crag mass toward the center of the pit was nearly obliterated under flows and only a small remnant of the small crag in the northern depression protruded above the fresh floor. The west arm pond was smaller. The ponds were mostly crusted over but occasionally a somewhat explosive fountain would break through the crust of the southwest pond. Some small rock falls took place. The areas smoking lay on the north side of the southwest pond, the west end of the main lake, at the north lake cone and at the north depression crag remnant. The margin of the pit showed no changes.

In the Whitney Laboratory for the week ending at 8 p. m., Nov. 22, 1918, there have been registered seventy-four local earthquakes and spasms of trembling, sixty-nine of which occurred during the twenty-four hours ending at 8 p. m., Saturday, Nov. 16, the day of maximum lava subsidence. The others were two shocks in the early morning, Nov. 17, and three slight spasms of trembling on the 17th, near midnight of the 18th, and in the morning of the 19th. A pronounced teleseism was registered at 7:25 a. m., Hawaiian time, Nov. 18, which gave evidence of origin about 8550 kilometers away. The microseismic vibrations increased strongly during the week, especially in the north-south azimuth as usual, and coincidently with a spell of calm weather with some very light southerly breeze. Increase of microseisms with such weather has been noticed before. Apart from the spasms of trembling above noted, the harmonic microtremor showed slight increase Nov. 20-22. The clinograph showed increase of tilt to the west until Nov. 21, then the pendulum moved slowly east with gradual decrease of the diurnal fluctuations. In the meridional azimuth there has been further slow northward tilt.

HAWAIIAN VOLCANO OBSERVATORY, Nov. 30, 1918.—The tendency reported last week for the net movement of the lava column to be downward for the bench magma and upward for the lake magma continued until Nov. 25. Then came a marked change to sharp rising of the entire lava column, the crags and floors lifting faster than the lakes. All of this has confirmed the expectation that the November subsidence, in accordance with precedent, would be a temporary one. An interesting feature of the recovery recalling again the events of last spring, has been the lagging of the stiff crag- and floor-lava behind the rise of the liquid lava by about ten days. The liquid has risen in flooding spurts with diminishing volume, while the stiffer floor matter has shown rising tendency between these spurts with very marked increase in its speed of rising as the liquid spurting spells dwindle.

The clinograph has again demonstrated perfect accordance between the west-east tilt and the measured fall and rise of the bench magma. Its movement appears to be independent of the spurting of the liquid lava. This accords with the supposition that the

liquid lava is relatively local, that the bench magma is more representative of the deep lava column under Mauna Loa, and that the tilting measured is due to a swelling up or shrinking back of the heavy stiff body in the fissures under the center of the Island of Hawaii. This stiff central fluid from which the filling of the Kilauea shaft is but an offshoot, may be expected to move much more gradually than the lava in Halemaumau, this latter being subject to sudden fluctuation due to surface release of pressure. The clinograph maxima were precisely accordant with the great subsidence and the following recovery, but the progress of tilting between the turning points was much more gradual. This leads to the supposition that the excessively rapid drop of Nov. 8 and 9 was merely a culmination of the gas effervescence which had begun with the sudden lava flows of Nov. 2 and that all of this production of liquid lava was a local culminative gas-heating effect due to release of pressure when the main lava body in the deep fissures reached the limit of its upward squeezing.

A summary of November measurements with reference to the southeast rim of the pit is as follows:

Nov. 5, elevation central crag, 76 feet; depression lake, 17 feet; depression of central floor, 12 feet.

Nov. 16, depression central crag, 142 feet; depression lake, 239 feet; depression of central floor, 230 feet.

Nov. 20, depression central crag, 152 feet; depression lake, 226 feet; depression of central floor, 216 feet.

Nov. 22, depression central crag, 158 feet; depression lake, 235 feet; depression of central floor, 225 feet.

Nov. 24, depression central crag, 153 feet; depression lake, 198 feet; depression of central floor, 198 feet.

Nov. 26, depression central crag, 155 feet; depression lake, 185 feet; depression of central floor, 175 feet.

Nov. 28, depression central crag, 104 feet; depression lake, 173 feet; depression of central floor, 165 feet.

Nov. 30, depression central crag, 80 feet; depression lake, 140 feet; depression of central floor, 125 feet.

Examining first the measurements of the past ten days we find Nov. 21-22 crag subsided 6 feet, or 3 feet per day; lake 9 feet, or 4.5 feet per day. Nov. 23-24 crag rose 5 feet, or 2.5 feet per day; lake rose 37 feet, or 18.5 feet per day. Nov. 25-28 crag rose 49 feet, or 12.25 feet per day; lake rose 25 feet, or 6.25 feet per day. Nov. 29-30 crag rose 24 feet, or 12 feet per day; lake rose 33 feet, or 16.5 feet per day. This exhibits the familiar alternation between bench and lake magmas. The actual turning point of the bench magma as a whole, checked by measurements on other crags, was Nov. 25-26 and its real movement Nov. 21-25 was a slight depression with much drowning by lava floods. The lift of the bench magma from Nov. 26 to 30 was really approximately 15 feet per day.

It appears then that the lakes and floors reached their lowest Nov. 16, but the bench magma remained low to Nov. 26. The floor until the 25th was built up largely by flooding, thereafter it was lifted bodily. From Nov. 16 to 25 there was a gain of 55 feet of actual elevation of the floor by flooding while the bench magma slowly subsided 11 feet, making a net construction by lava flow veneers of 66 feet.

After that, Nov. 26 to 30, the lake rose 9 feet per day, the floor 10 feet per day and the central crag 15 feet per day. The relief of the central crag has been as follows:

Nov. 5, crag stood 93 feet above lake, 88 feet above floor.

Nov. 16, crag stood 97 feet above lake, 88 feet above floor.

Nov. 25, crag stood 30 feet above lake, 25 feet above floor.

Nov. 30, crag stood 60 feet above lake, 45 feet above floor.

On Nov. 24, 1918, at 11:30 a. m., there was almost no fume and from ten fountaining areas the floor of the pit rumbled and clanged like a factory city. The lake outlines were drowned under the spreading floods, intense heat rose from the glowing surfaces and the encroachment of the liquid lava on the crags was much the greatest since 1916. In the main lake and southeast pond areas the streaming was eastward toward fixed fountains. A flow was pouring northeastward from the central region and another westward from the north lake. The southwest region was

stagnant. From time to time there was much cracking and foundering.

The northeast valley was clearly the lowest place in the pit but the flows had not yet invaded it. All the rest of the floor was one vast pool of live lava patterned with festoons or with the smooth product of the cracking and foundering process. From the southeast region flows had begun to trickle into the south chasm, the central steeple had become isolated from the central crag mass by the floods about it and only very small scarps remained of the north and south ends of the west valley ridge and of the elongate portion of the western crag mass. The middle promontory of the northeast crag mass entirely submerged as were the north central rocks, the old southeast cone and the west central floor cone of recent development.

The main lake was outlined by four fountains and an eastward streaming place at the site of the former narrows. The southeast pond was marked by bubble fountains beside a small spatter heap and the southwest pond by fountains and spatter on its south side and one fountain at the northwest corner. The west arm pond was a small circular basin with a spatter rampart on its eastern side, east of which a small orifice was blowing like a locomotive. The northwest pond was marked by a hissing black cone and the north lake by a small fountaining pool with a large dome east of it. The noises were of hissing, plashing and pounding. Whitish vapor rose at the north crag, the central steeple, at the south end of the west crag mass and at the south and southwest talus.

The new flood abutted directly against the talus north, northwest and west, covering the whole of the west valley and the sloping southern floor was covered at its two ends. Southeast the new flows lapped against the large blocks of rock at the foot of the cliff.

On Monday, Nov. 25, at 6 p. m., the flows had spread to the north-east valley through the gap at its northern end and the western crag mass was drowned with the exception of its summit knob. The entire western escarpment was now submerged. At intervals the west arm pond sent up rocket sprays of glowing lava 50 feet into the air and smaller explosions occurred at irregular intervals. On the north and east sides of the southwest pond its margin was elevated as though the central crag mass were rising, but west and south the pond merged into a flow which extended around to the west arm depression. The main lake was a small oval pool with banks 2 feet high and four spatter domes where fountains and flames played. The north lake half dome was hung with stalactites and the southeast pond cone was flaming and hissing. There were flames also at the west arm pond and at the north cone and everywhere were glowing live flows and signs of high gas pressure and much gas combustion. The fumes were very thin and the noise of slides had mostly ceased, but the remnant inner ledges of the recent high level lava on the south-southeast and north had fallen since the previous day.

On Nov. 26 at 6 p. m., the glowing fresh flows were fewer, the lakes east and southeast showed deeper inner pits and the central region north of the central crag mass appeared dark as though the floor there were lifted. Farther north, west and northeast the glow of fresh flows was bright. The central crag mass appeared higher. Flames and fountains were much before but the southwest pond again showed a definite margin 5 feet high on the south and west and the main lake banks were of similar height. The southeast cone had become a flaming filagree and there was a very marked patch of glowing filagree crust on the north bank of the main lake. The spraying from the west arm pond had decreased and there was some high spraying at the southeast corner of the main lake. The grotto on the north side of the lake was hung with stalactites. The north lake cone was bright but not active.

On Thursday, Nov. 28, 1918, at 11 a. m., the flowing had ceased and pronounced lifting and cracking of the floor and crags had set in. The whole central floor as far north as the north lake cone and east and west to the talus margins of the pit was sulphur stained along small cracks and very pronounced upward swelling was exhibited as a pressure ridge along the line of the chasm between the southwest and southeast ponds

The final flooding, presumably of the night of Nov 26, had left new festooned flows extending to the talus southeastward from a large cone at the southeast pond site and southwestward from the southwest pond, driblet flows at the northwest margin of the floor and a broad flow extending from the north lake cone southward and eastward so as to flood across the saddle of the northeast crag mass down the backslope into the northeast valley. Glistening spatter domes had been built at the southeast corners respectively of the main lake and the southwest pond. This pond was triangular as before with a low southwest shore three feet high and a 15-foot cliff on its north and east sides lifted by the swelling up of the central crag mass.

The immediate effect of the uplift, as usual in such cases, was to start collapse and enlargement of lakes, and a new small pond connected with the east pool by a tunnel beneath and forming a panhandle to that pool had opened on the northwest side of the central steeple. The walls of this pot and of the main lake were 8 feet high. Some banks were seen to collapse at the margin of the main lake.

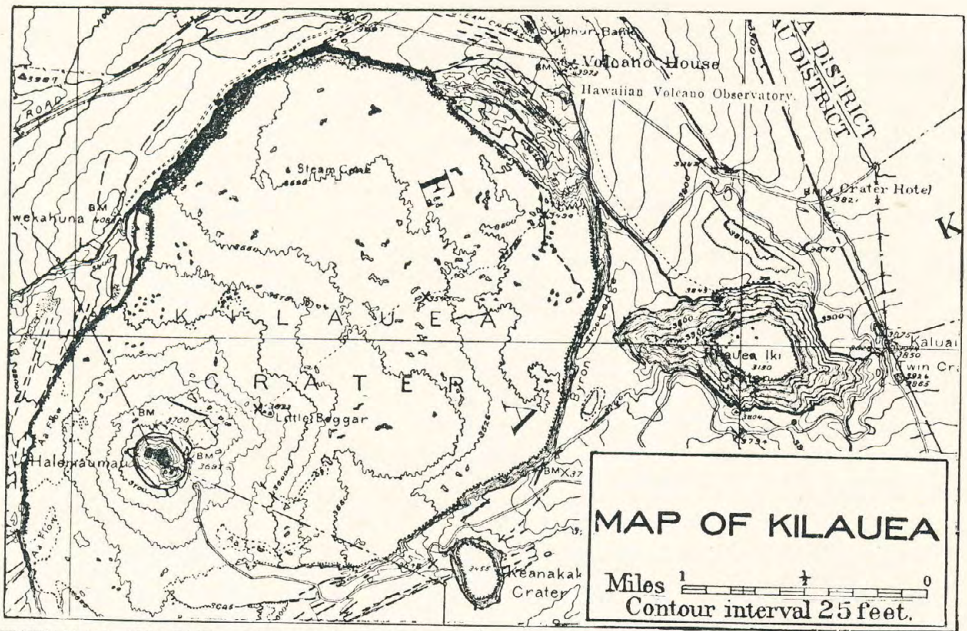
The only wall valleys now defined were southwest and northeast, the former extending along the old south floor and thence westward, newly defined by the lift of the south chasm ridge and of a new escarpment on the east side of the tunnel connecting the southwest pond and the west arm pool.

The north cone was yellow with solfataric deposits and no pond was there visible. The main lake had widened, streaming was eastward and marginal fountains played north, south and east. The small central pond was fountaining. The southeast pond cone was hissing from one small glowing crack. The southwest pond showed a glowing cavern at the northwest tunnel, it was crusted over most of the time but the crusts occasionally broke up. Smoke had increased, especially at the southeast corner of the main lake, north and west of the central crag mass, and at the base of the north crag. Some rain steam rose from the talus, due to the excessive downpour of the previous day when nearly nine inches of rain had fallen in twenty-four hours. The central crag showed increased height, the northeast crag mass was more moderately raised and the west crag, almost submerged, showed no signs as yet of differential lifting.

In the Whitney Laboratory of Seismology for the week ending at 8 p. m., Nov. 29, 1918, there were registered local earthquake shocks Nov. 23 at 10:01 a. m. and Nov. 26 at 9:51 a. m., and two tremor spasms Nov. 24 at 5:37 a. m., and at 4:53 p. m. Microtremor has otherwise been ordinary. Microseisms increased in amplitude to very strong Nov. 25-28 during a southwesterly wind and rain storm and abated thereafter, the north-south component always the stronger, but the east-west also becoming very pronounced Nov. 27-28. The clinograph showed continued westward tilt to Nov. 25, stationary condition Nov. 26, and on Nov. 27 strong eastward tilt began which continued and increased to Nov. 29 inclusive, and thereafter. The diurnal fluctuation was very slight Nov. 25-28 and increased somewhat after that time. The meridional tilt continued northward.

Very respectfully,

T. A. JAGGAR, JR.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1918 there were about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly bulletins since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The monthly bulletin is sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund for geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol a, or max. a, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.

WEEKLY BULLETIN
OF THE
Hawaiian Volcano Observatory

Vol. VI. HONOLULU, HAWAII, DECEMBER, 1918 No. 12

HAWAIIAN VOLCANO OBSERVATORY, Dec. 7, 1918.—During the week ending Friday, Dec. 6, 1918, the Halemaumau lava column has continued to rise over 3 feet per day with liquid flooding of the wall valley margin of the floor area dominant over bodily uplift of the bench magma. Both bench and lake magmas have risen, however, the lift of what was formerly the floor surrounding the inner pit of the main lake reaching such proportions as to convert the bottom of the crater into a pyramid or cone with the lake pit at its summit. This condition reached its maximum Dec. 2 when the lake occupied a cup in the apex of the uplifted floor some distance to the east of the center of the pit, while north, west and south the margin of the floor area subsided, reviving the wall valley in a great horseshoe. Later the liquid lava welling out from numerous vents tended to fill this horseshoe-shaped hollow. When the upheaved pyramid was at its greatest relief the pit wall on the east side was much lower than elsewhere, but the filling of the horseshoe reduced this difference. It was evident that the bench magma uplift took effect most strongly under the lake bottom, and this was not at the center of the pit but towards the east and southeast. Such an effect, if continued, would of course produce overflow first on that side of the pit and this is just what happened last February. The crag wall northeast, the so-called central crag mass lying south of the center of the pit, and the west crag were all borne on the slope of the upheaved pyramid and as peak of the pyramid, were chiefly lifted, parts of the flaw executed a tilting movement rather than steady elevation. Consequently the east ledge and the central crag, nearest to the lake, the but the old northwest crags on the side of the wall valley were depressed and partially drowned beneath the new fill. The fume from the pit remains thin but smoking vents have increased in number.

The measurements for the week were as follows:

Nov. 30, depression central crag, 80 feet; depression lake, 140 feet.

Dec. 1, depression central crag, 66 feet; depression lake, 126 feet.

Dec. 2, depression central crag, 68 feet; depression lake, 125 feet.

Nov. 6, depression central crag, 59 feet; depression lake, 116 feet.

The inner cup occupied by the lake had walls 15 feet high Nov. 30 and Dec. 6, and 20 feet high Dec. 1 and 2. These measurements indicate that the central crag rose 21 feet in six days, or 3.5 feet per day, while the lake and its inner cup rose 24 feet in six days, or 4 feet per day.

On Saturday, Nov. 30, 1918, at 11:30 a. m., the conspicuous feature in Halemaumau was strong uplift of the crater floor in an arch with its apex at the margins of the main lake and a complex of opening crevasses near the summit of this pyramid lay between the main east talus, opening of the wall crack behind it and welling out of liquid lava there. Large crevasses in the central region of the floor yawned open in lines from the north lake southward and from the main lake westward, and there were other crevasses east and north of the central crag mass, which was itself greatly raised. The northeast crag mass was somewhat lifted so as to deform the fresh flows across its saddle. One pronounced avalanche fell from the west wall of the pit and numerous rock adjustments indicated motion in the bench magma.

WEEKLY BULLETIN
of the
Hawaiian Volcano Observatory

Published Monthly at Honolulu, Hawaii, by the Hawaiian Volcano Research Association

L. W. de Vis-Norton.....Secretary

Entered as second-class matter January 20, 1914, at the post-office at Honolulu, Hawaii, under the Act of August 24, 1912.

The main, central and southeast ponds were each depressed about 15 feet within their cups and the basins of the north and southwest lakes were somewhat shallower. There were occasional falls of rock from the west bank of the main lake and in that direction the lake was enlarged by union with the small pot which had opened on the north side of the central steeple. Still farther west the central pool was again open as a small pond, as were also the southeast and north lakes. Streaming was southwestward in the southeast pond and in the main lake it was indefinite, pouring inward toward the fountaining grottoes from a central crust except when the crust broke up to develop central fountains.

Wall valley flows had begun to make extensive fills from vents at the sites of the three former gateways north, east and southwest. The southwest and west arm ponds were flooding right and left along the base of the pit wall, the flows extending to the base of the northwest cliff and the whole length of the south valley; the west crag knob was now nearly submerged. The northern lake vents were flooding the north and northeast wall valleys, greatly raising and widening the northern part of the latter. The eastern vents made three talus cascades with outwelling at the top of the talus east-northeast, east and east-southeast. The two northernmost of these orifices were surmounted by hissing spiracle cones and the eastern one showed aa at the margins of the pahoehoe festoons that trickled down the sliderock slope. These flows tended to fill the southern end of the northeast valley. It was evident that the talus was lifting away from the wall where the east cross ledge had lifted in August and the gaping wall crack could be seen in places where it was not filled with the fresh lava. The filling of the wall valley had now almost completely submerged the upturned floor slabs of the November subsidence.

On Dec. 1 at 1:30 p. m. the tumescence under the main and southeast lakes had become so marked as to make the inner main lake cup the distinct summit of an unsymmetrical cone, just as Halemaumau is at the summit of a cone in Kilauea crater. This effect was most striking when the pit was viewed from its high northwest rim. From this viewpoint the floor pyramid was seen to be crowded over against the eastern wall of the pit and there lifted most strongly while the long slopes of the uplift swept down into the foreground, and right and left the crags were seen to be borne upon the flanks. Still farther right and left the northeast and south valleys made the horns of a crescent of fresh flows, the widest part of which was filling the entire northwestern .half of the bottom of the pit Around the lake as the center of the uplift there were radial cracks and these joined a long transverse crevasse extending from the north lake to the southwestern ponds. In the background, symmetrically grouped behind the pyramid, were the festooned talus cascades, the highest vents for liquid lava above the side where the uplift was highest. Here also the cliffs were less than a hundred feet high, whereas in the foreground under the observer the northwest cliff was much higher.

There was steady hissing from the east-northeast talus vent. The southern most of these vents had extended itself southward so as to make a new cascade flooding the wall valley under the southeast station. Such a valley now encircled the floor except for the interruption of the east talus. The southwest pond was fountaining on its south side and overflowing there continuously. The west pond showed fountains occasionally and adjacent vents hissed. There had been some collapse of the scarp east of it. There was fresh lava in the northeast and south valleys, the

northeast fill being flatter and higher. The main lake walls were greatly increased in height, rising some 20 or 25 feet in places. There were the usual grotto fountains and a glowing vent had developed high up the wall above the northeast grotto. The north lake was now an elongate oval chasm filling, fountaining at its northeast corner. The central crag was tilting southward and smoke rose from cracks at its southern base. The fresh floor lavas were snapping, there were occasional avalanches and rocks were in motion on the crags. Large tumbled crevasses had developed along the lines connecting the main lake with the north and west ponds respectively. The valley fills southeast and south had nearly met.

On Monday, Dec. 2, at 3 p. m., it was evident that a new spell of development of liquid lava at the expense of the bench magma was in progress, for the lift had ceased and the filling greatly increased. Doubtless the wall valley bottoms were sinking and the wall cracks pulling open. Lava was pouring down the southeast talus, there were fresh cascades from the hissing cone northeast, the northeast valley was filled higher with its center smooth by cracking and foundering. The fresh flows were trickling southward on the northwest floor and the southwest wall valley was covered with new lava from the southwest pond.

The lakes were all more depressed within their basins, the main lake 25 feet, the southeast pond 15 feet, the southwest and north lakes 10 feet, and the west pond 4 feet. There was a fountain on the south side of the latter, in the main lake there was little activity except at the south grotto, the southwest and north ponds were quiet, and the liquid in the southeast pit poured rapidly southwestward as though into a cavern. Occasionally the northeast grotto of the main lake became active, but the streaming was inconstant and at one time it was westward. Great volumes of smoke rose along the immediate southwest base of the central crag, there was some slight rock-sliding from the southwest wall of the pit and the floor crevasses had widened and become displaced with opposite walls at different levels.

On the evening of Dec. 4 at 7 o'clock, after the violent storm of the preceding two days, it was evident that there had been great increase of liquid lava effervescence. The fume had been notably thinner in this interval. There was now a pot in the high talus east containing a continuously fountaining puddle and snaky flows trickled down the slope to join a glowing pile of lava beneath. The high vent northeast was puffing like a locomotive and beneath it the northeast valley fill was glowing and increased in size. At the base of the northwest wall of the pit two streams were pouring from a wall crack vent feeding another broad glowing fill. The south valley fill glowed dimly and was now merged with the southeast fill. The southeast pond had sealed up and become a glowing and flaming cone. The main lake had high walls and exhibited the usual activity. The north lake was quiet with blue flames at its margin, the southwest pond was moderately active and a glowing cone stood above the west pond. The northeast valley floor was now level and continuous with the floors north and northwest.

On Friday, Dec. 6, 1918, at 1 p. m., the lava had entered upon a noisy stage owing to the confining of gas by the solidifying liquid lava, and the several vents east, north and southwest were roaring like a freight yard full of locomotives. The wall valley horseshoe was floored continuously with a broad fill so that the western pit wall was now only slightly higher than the eastern wall. The base of the old crag was submerged, but the west crag knob was still intact. The inner pyramid of uplift now stood as an island in the ring of new lava.

The sources of the flow filling have been as follows: (1), the eastern wall crack cascades; (2), the flaming cones of the north lake area; (3), the west arm pond, now surmounted by a very large blowing cone; (4), the southwest pond, small, circular and showing fresh flow festoons pouring east and west from its southern lip; and (5), the southeast pond, a black heap with a flaming orifice.

The puffing was continuous from a cone where the open puddle had been

at the top of the southeastern talus. There was occasional harsh puffing from the southeast cone, the west pond cone, and loudest of all from a cone at the south end of the north lake which emitted a roar about once a minute which could be heard two miles away. At each explosion lava and flame could be seen spurting from the vent which stood at least 10 feet above the north lake.

The main lake showed a new inner floor bench 3 feet above the liquid and a 12-foot wall above that. The liquid was mostly covered with dark skin showing streaming patches where the current poured toward the several grottoes north, south and southeast, and on one occasion a marked westward streaming was observed when the crust broke up. The cracked region extending westward from the lake was smoking strongly and the smoke southwest of the central crag had diminished. The southwest pond had 3-foot banks and was somewhat active. Fountains could be seen at the north end of the north lake where a high spatter rampart had been built and the older north lake cone stood farther east on the floor. There were continuous small avalanches from the south-southeast wall of the pit which led to a heavy fall of a remnant shelf of November lava there at 2 p. m. This avalanching recurrent during the week indicated subsidence under the wall valleys.

In the Whitney Laboratory of Seismology a distant strong earthquake was registered at 10:28 p. m. Dec. 5, with greater amplitude of the long waves in the north-south component than in the east-west. The evidence of distance of origin was not shown. Local earthquakes were registered at 12:38 a. m. and at 3:29 and 5:57 p. m., Nov. 30; and a small shock at 4:28 a. m., Dec. 5. Microseisms increased to excessively strong Dec. 3-4 at the time of the northeast gale and decreased thereafter. The rhythmic microtremor tended to increase at the same time with the microseisms, but reached its maximum while the latter were decreasing and continues fairly strong at the time of writing (Dec. 7). Even the north-south component showed this tremor, which is unusual. Ordinarily the microtremor is pronounced in the east-west azimuth and the microseismic motion in the north-south.

The tilting movements were as follows: Nov. 30-Dec. 2, very strong east and north, with increasing diurnal fluctuation; Dec. 2-3, slight west and south, with strong diurnal fluctuation; Dec. 3-5, steady east and north tilt, with slight diurnal variation; Dec. 5 to the evening of Dec. 6, strong west and south, with slight diurnal movement, followed by recovery to the east and north. The net change of tilt for the week was a positive east and north movement and the deviations from this above recorded appeared to check consistently with the alternation between rising bench magma and rising lake magma, the latter agreeing with the west and south stages. In other words, the production of lava flows corresponded with sinking or stationary times in the main lava column.

HAWAIIAN VOLCANO OBSERVATORY, Dec. 14, 1918.—The second week in December has produced another of the violent reactions from uplift to temporary subsidence with liquid flooding, repeating the process described last week but with the effervescence, through blowing cones, of the gas-and-liquid floods still more intense so as to greatly increase the conquest of the crags by pooling lava. As a result the old western, southern and northern crag remnants are entirely submerged under a new flattish floor, huge blowing cones are all that mark the flood plain sites of some of the ponds, the talus is mostly submerged and the only crags that remain, besides the great central mass, are the peaks of the east ledge and the north scarp. The fume has again decreased to a very thin veil and twenty or more fountaining and puffing places are visible at one time.

The measurements for the week were as follows:

Dec. 6, depression central crag, 59 feet; depression lake, 116 feet.

Dec. 9, depression central crag, 51 feet; depression lake, 116 feet.

Dec. 12, depression central crag, 55 feet; depression lake, 115 feet.

Dec. 13, depression central crag, 47 feet; depression lake, 99 feet.

From Dec. 6 to 9, three days, the central crag rose 8 feet, or 2.7 feet per day, while the lake had actually risen 4 feet and sunk 4 feet, as indicated by a measurement Dec. 8. Dec. 9 to 12, three days, the crag sank 4 feet, or 1.3 feet per day, while the lake rose one foot. This moderate subsidence of the bench magma inaugurated a tremendous spurt of liquefaction, for the next day, Dec. 13, the lake had risen 16 feet and the entire circle of wall valley had been filled to produce the appearance of horizontality, while the crag had risen 8 feet, probably in response to the inward squeeze produced by the peripheral weighting. This bench magma uplift under the lake bottom as a center still kept the lake margin at the summit of an inner flat pyramid, for on Dec. 13 the southeast pond level was 3 feet lower than the edge of the main lake at a distance of 90 feet, and the base of the north lake cone 13 feet lower at a distance of 400 feet. These measurements imply that the seemingly flat flood plain really maintains a three per cent radial grade away from the lake basin as a center. It will be observed that for the seven days ending Dec. 13 the lake rose 17 feet, averaging 2.4 feet per day and the central crag 12 feet, averaging 1.7 feet per day; but practically all of this in the case of the lake happened during the last day of the period and two-thirds of it in the case of the crag.

On December 8, 1918, at 3:30 p. m., after a rainy day there was great increase of smoke at the pit, the bench magma was rising and the liquid lava appeared rather stagnant. The filling had continued during the preceding forty-eight hours so that the old north crag was surrounded by new floor, the northeast fill was flush with the saddle of the northeastern crag mass, the east talus vent and hardened flows from it were glowing and a fiery pot was open at the southeast pond locality. At the northeast wall vent a large double cone with a high spire appeared. The lake inner wall was 20 feet high at the west and 15 feet high at the east. The activity was mostly along the south bank with streaming in that direction and a glowing cavern overhung the western end, showing a curtain of stalactites. At long intervals the north central cone emitted a sharp hissing noise. In the evening the east talus vent was reported flowing.

At noon on Monday, Dec. 9, the increase in smoke from the pit was remarkable, coinciding with the climax of lifting bench magma. In general the pit was quiet and smoky. Puffing from the north central cone had ceased. Greatest volumes of fume rose from the central pool region where there was an open pot and tumbled crevasses over the western extension of the lake beneath. The lifting effect was shown even in the fresh smooth flows of the northeast fill which were arched up and cracked. A crescent of floor north of the lake with scarp facing southwest appeared to be rising, bounded by the western and central crevasses, and if continued this would renew the northeastern crag mass.

Flows had ceased but the adjustments of the great pool of liquid lava beneath the crust of the northeast fill produced an outflow from the edge of the pool which poured into one of the large cracks in the backslope of the north crag.

The main lake showed much bubble fountaining along its south shore and occasional large central fountains flung up stringy melt. The southwest pond region had developed lumpy cones and much smoke, the southeast region was full of smoke, the north lake was inactive and the east side of its chasm appeared rising. This was the last day to show the remnant of the west crag knob unsubmerged.

There was a heavy rain storm Dec. 10 and 11 but glimpses indicated that the fume from the pit was somewhat thinner as though liquid lava was making again.

On Thursday, Dec. 12, 1918, at 4 p. m., the crags were lower but flows had recommenced. The northeast wall vent had piled up the northeast valley fill so as to send a flow through the saddle of the northeast crag mass which then poured northward, exactly the reverse of what had happened Nov. 26 when the north lake had sent a flow across this saddle eastward.

Small rock slides especially towards the north and west occurred all after-

noon showing that the wall valleys were subsiding. The liquid lava, however, was rising rapidly so that the inner walls of the main lake between 6 and 7 p. m. decreased in height from 15 to 5 feet and less. The rise was accompanied by great increase of gas pressure with violent spraying from a circle of six blowing cones all around the pit and finally tremendous river-like flows which broke out in three places.

In the early afternoon the north central cone gave out prolonged blasts of gas from a vent in its side which could be seen spraying lava. Farther north a very high spatter heap ejected spray horizontally northward. The southeast cone exhibited two open puffing vents, the northern one a spiracle three feet high. The southwest pond was small and circular with many bubble fountains and a large puffing dome lay southeast of it. The west pond cone was a broad cylinder 12 feet high, at first quiet. The central pond was open with a broken sagging crust between it and the main lake. The latter showed turbulent travelling fountains in the middle and towards the west end where east and west streaming met. Later in the evening the streaming was continuously eastward. Frequently there was violent bombardment of the southwest wall of the lake, the liquid streaming from under thin black crusts incessantly blistered and ballooned through the action of rising gas beneath. The entire pit became increasingly noisy with rumbling and puffing from the fountains and blowing cones. The smoke rising from the cracked areas was less dense than before.

After 5 p. m. the increase of gas pressure took effect in the rising of the main and central lakes, a large flaming crack was revealed between them and the group of spiracles which constituted the northeast wall cone opened low down on the pit side and ejected a rapid cascade which spread into a leaf-shaped flow on the northeast floor. The west arm cone now began throwing up liquid lava through its wide circular summit orifice and suddenly a dome of liquid spurted up through the ground beside it on the south and started a broad flow northwestward into the wall valley. This boiling source continued active for many hours. The southwest pond in a series of impulses of overflow finally poured over its ramparts in all directions, while the flaming cone southeast of it increased its violent spurting. The overflow settled down into a continuous broad flood of lava which united with the western flood and poured eastward through the south valley. The southeast wall vent revived and the southern of the southeast pond vents started to build a cone. This, the southwest and the north vents all threw spray over 50 feet. The main lake overflowed into the gaping crevasses of the southeast floor making a most spectacular display. The north central cone vent became quiet when the others burst into activity.

The north lake chasm was now a group of lumpy ramparts with the two cones as its active vents. The old north crag summit still stood above the flood but the west crag was gone.

On Friday, Dec. 13, it became evident that this spurt of the preceding day had initiated a very pronounced crisis of rising. At 3:30 p. m. the flooding was still in progress through the blowing noises were less strong. The remaining crags had risen, the floors had broadened in all directions and the only remnant of the uplifted November surface was in the region northwest of the main lake. The old south and old north crag remnants were submerged. The southeast pond district was a flat of glowing lava with a fountain in the midst. The flood had risen high around the base of the central crag, and the east ledge and north crag were only small islands in the flood.

The main lake and central pond were joined by a common flooding but the central steeple and its platform remained above them. The base of the northwest wall of the pit appeared to be the lowest place and the floods were spreading in that direction.

The west arm cone was a 7-foot dome with a glowing summit. A large double cone splashed through a gash on top where the northeastern shore of the southwest pond had been and another cone continued spurting south of it. At the north end of the north lake chasm an enormous cone 18 feet high had been built with an open triangular

pot fountaining in its crest. Two other cones spurted farther north. The northeast wall cone showed a complex of spatter lumps containing a splashing pot which overflowed for a short time. The southeast wall cone had increased in size and stood on an elongate terrace of wall crack heapings at the top of some 20 feet of remaining talus. Most of the talus elsewhere was drowned. The outline of the main lake was defined by four spatter ramparts, one of which at the north collapsed and gave vent to a short festooned flow. The streaming in the lake was eastward. Fume was very thin, the smokiest place being at the north base of the central crag, and rock sliding had ceased. The night blow was very bright.

In the Whitney Laboratory for the week ending at 8 p. m., Dec. 13, 1918, the seismic events have been limited to a small local earthquake Dec. 10 at 2:56 p. m., and two telesciscms close together, the first a slight record at about 7:52 a. m., and the second a long one, beginning about 8:24 a. m. on Dec. 9. The origin would appear to be some 7300 kilometers away. Microtremor of the continuous sort increased after Dec. 11 and continued strong. Microseisms increased to Dec. 10-11 and decreased thereafter, always stronger in the north-south azimuth.

The clinograph registered an end of the westward tilting Dec. 7, slight eastward tilt to Dec. 9, very slight westward tendency to Dec. 11, and a resumption of east tilt Dec. 12-13. The daily range was strong until Dec. 7, slight Dec. 8-11, strong again after Dec. 12. As usual the more prolonged movements coincided with the rise and fall of the bench magma in Halemaumau.

HAWAIIAN VOLCANO OBSERVATORY, Dec. 21, 1918.—The week preceding the solstice at Halemaumau continued the rising spurt described last week until Dec. 14, followed by 3 days subsidence of the bench magma, the lake magma participating in this only on the first day and thereafter rising. On Dec. 20 both lake and crag were rising. Only one crag remains, the central one, as the peripheral lava floods have drowned the others. The bottom of the pit is now a continuous circular floor about 90 feet down, with the crag peak standing on it like an island 30 feet high, the three lakes east, southwest and north small pools occupying slight elevations, the eastern or main lake the largest and the other two acting as sources of many flows on the floor. The floor margin at the base of the walls has been filling extensively, with the filling compensated by subsidence below and probably by underflow toward the center, where the crag and east pool basin are lifted. The northeast fill is especially high while the western floor remains low.

The measurements for the week were as follows:

Dec. 13, depression central crag, 47 feet; depression lake, 99 feet.

Dec. 20, depression central crag, 55 feet; depression lake, 86 feet.

The net movement in seven days, therefore, was crag down 8 feet and lake up 13 feet. Other measurement showed that the north crag sank 6 feet and became submerged on the fourth day. The north lake floor and cones built up 33 feet during the week, and the southeast pond area 12 feet.

The rising and falling proceeded as follows: Dec. 13-14, 1 day, central crag went up 3 feet, north crag down 1 foot, lake up 2 feet; Dec. 15-19, 5 days, central crag down 13 feet, north crag down over 5 feet, lake up 11 feet, north lake floor up 21 feet; Dec. 19-20, 1 day, central crag up 2 feet, north crag submerged, lake stationary, north lake floor up 4 feet.

On Saturday, Dec. 14, 1918, at 5 p. m., rising and flooding continued with hissing, puffing and splashing noises and thin fume. The west cones were splashing, the southwest pond was sending a broad festoon flow northwestward. The freshest flows were west and south, but the building up elsewhere had nearly drowned the east ledge and left the north crag small. A large cone-shaped heap replaced the central pool, with a fountaining summit cap. The main lake was nearly circular and streaming from a narrow western cove to spatter ramparts north, northeast, east and south. The northeast wall cone was half submerged and changed in shape, the eastern one built higher, and a new active one had given vent to flows under the

south-southeast wall of the pit. The southeast pond was replaced by an inconspicuous spatter spot. A small remnant of the old south crag could still be detected. The main cone of the north lake was smaller and converted into an irregular group of cones.

At 3 p. m. Dec. 15 the filling and widening of the outer ring around the remnant of the lake margin uplift continued, so that the only trace of the weathered November surface was a small tumbled area northwest of the main lake. The southeast pond cone was slightly larger, the rampart grottoes of the main lake were building cavernous half-domes, the large central cone was still in place, there was fountaining at the southeast pond and north lake sites, and the east wall-cone was hissing and flaming slightly. A broad festooned flood continued to pour westward from the southwest pond, the main lake was brimming full to its banks and streaming eastward, new toes of live lava pushed out as flows from under crust in the south, west central and northwestern regions, and the northeast floor was a smoothly crusted extensive area showing the tracery of recent cracking and foundering of its crusts. The east ledge was now entirely submerged. The southwest pond in a spasm of rising overflowed its rampart eastward. Smoke rose from the central region and the north crag remnant and cracks had formed in the northeast floor parallel with the wall. The glow was bright at night and the general fume remained thin.

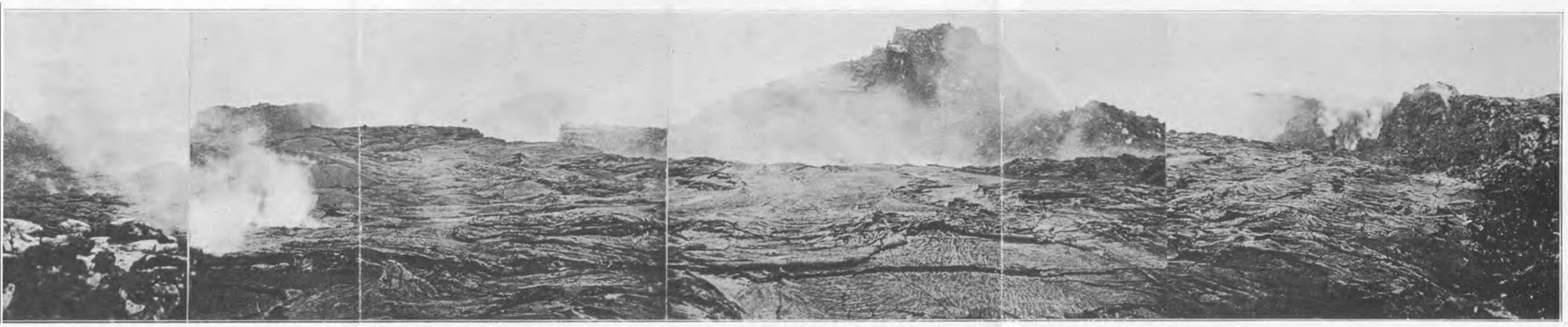
On Monday, Dec. 16, at noon, the flows lapped still higher up the walls of the pit and were bubbling up voluminously. A large dome fountain was spouting steadily on the south side of the north lake ones and sending a flood westward. The main lake overflowed its southern edge, the southeast pond was a bubbling spot, the southwest pond continued overflowing and large spatter heaps had built east of it. The central cone was now a roundish heap spouting on top, a hole spurted northwest of the north lake cones, little could be identified of the west arm cones, the streaming in the lake was eastward and an enclosed pot had formed on its southwest margin. The eastern wall cones appeared to be drowning themselves, the north crag was a very small remnant, the old south crag was wholly gone, and the last of the central floor crevasses of the November uplift was submerged. No talus blocks east were now visible. East and northeast the floor was smooth with cracks and founder pattern, the western fields were mostly pahoehoe trickle.

On Wednesday, Dec. 18, at 11 a. m., the marginal region appeared to be subsiding leaving the middle again in relief, fresher flows appearing all around the floor border, while the north central region showed a little cracking and gypsum stain. The east and northeast wall-cones were nearly submerged and the southeast wall-cone a fountaining puddle. The north crag was now wholly submerged. The southeast pond showed a glowing cone, the flows stood higher around the central crag, the central cone was gone, the north cones were inconspicuous and replaced by a flat crusted pool glowing on one side. The rim around the main lake stood 3 feet high, the streaming was eastward, and the southwest pond was an oval depressed three feet. A group of spatter heaps stood near the southwest pond. There were some moving flows northwest and northeast and some hissing, but the pit was much less active than before. Northeast and southeast there had been deep pooling, cracking, and foundering as before, the western region showing little of this. In the evening the pit was very dull.

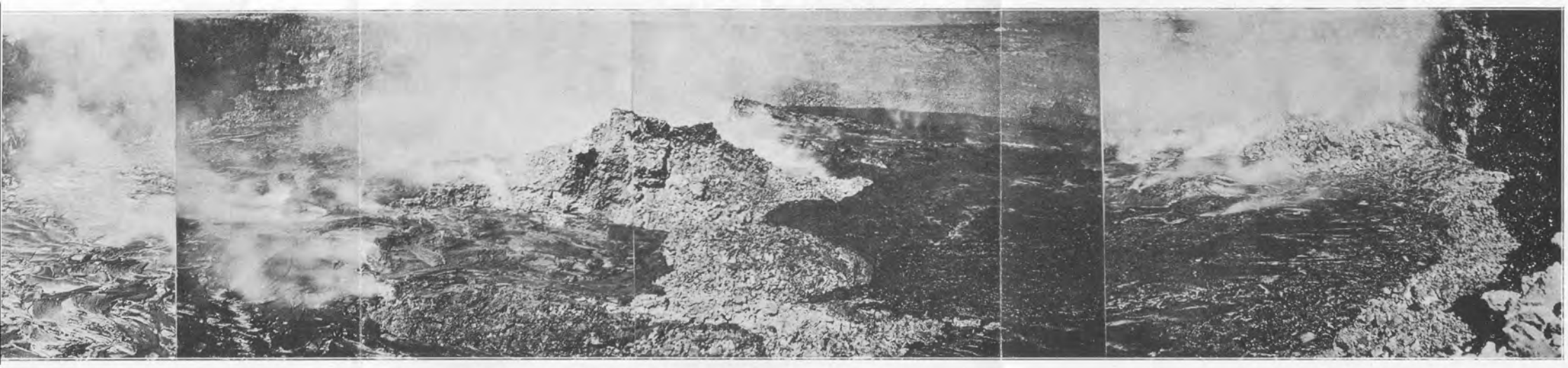
On Dec. 19, 1918, at 1 p. m., the crisis of subsidence of the bench magma had been passed, it had perhaps begun to rise, there was some increase of smoke near the central crag and a notable increase of gas pressure and blowing noises. Flows had continued and a noon rise was in progress, flows pouring out southwest and west. The main lake was flush with its margin and had recently overflowed its lip northwest, and its streaming was towards big grotto domes on the north, southeast, and southwest. There were small ponds at the north and southwest lake sites, and the central cone had reformed. Flows were trickling in various places and the hissing from the east, southeast and southwest cones was loud enough to be

HALEMAUMAU FROM THE SOUTH, BEFORE AND AFTER NOVEMBER SINKING.

—Photos Jaggar.



(1) September 26, 1918: Lava column high, partly above rim of pit.



(2) December 6, 1918: Lava column low, recovering by liquid floods. Note integrity of central crag mass, in spite of great subsidence.

heard a quarter mile away at the road terminus. The central steeple was now nearly gone. The eastern wall-crack cones had more or less reformed some distance out from the wall as the rising floods had widened the floor. The central cone was throwing up splashes and there was hissing from one of the main lake grotto domes.

On Friday, Dec. 20, at 3 p. m., the central region was lifting leaving the lakes depressed. The hissing was less and there was strong rumbling from the lake grottoes. The main lake margin was 2 to 3 feet high in shape an even oval, and there were high broad grotto domes on the east end where violent bombardment was going on. Streaming was radial from a central patch of skin, with strong inrush to southwest, to northeast and to southeast. There were occasional violent central fountains.

The southwest pond was an oval pit with the liquid lava five to ten feet below the rim, and the higher part of the verge on the east side showed deep overhang beneath and a grotto hung with stalactites where the liquid streamed eastward. Here a cone surmounted the edge, while from the opposite lower southwest edge a recent festooned overflow had poured. The west arm pond site was now a glow cone and another such flow had poured from it westward, these flows showing that the grade of this part of the floor was still to the west.

The north lake site showed a small fountaining area, a slumped crust and to the south of this a large breathing cone with glowing summit orifice. The active area showed a grotto with stalactites on the north side, the liquid within lying low. Recent flows from here had poured northwestward, and in some few places the front was pushing out live toes. The freshest flow was a large smooth area northeast and the northeast cone had revived and was spattering. The southeast pond cone and the east and southeast wall-cones were hissing a little. The central steeple was about gone and the floor about the central crag seemed to have lifted more than the crag making a ring depression about the latter. There were some fresh small rock falls along the south wall of the pit. Smoke holes had increased in number. There was some Pele's hair on the central floor and the central cone was inactive.

The week has been quiet seismically and the clinograph tilts first east, then west, then east again accorded with the rising, falling and resumed rising spells of the crags. Further experimental work in the Whitney laboratory has produced a first optical record of the vertical component seismograph, and a method of even, smooth smoking of the smoked paper sheets has been perfected.

HAWAIIAN VOLCANO OBSERVATORY, Dec. 28, 1918.—The week of the December solstice of 1918 was marked by a turning point from subsidence of the stiffer lava column or bench magma as represented by the central crag, for the crag summit reached its lowest of 57 feet below the southeast rim of the pit on Dec. 19. The lake of liquid lava, then 86 feet below the rim of the pit, rose 14 feet until Dec. 24 and thereafter became stationary. The crag rose 10 feet between Dec. 19 and 21, and for a week thereafter maintained an average level of 50 feet below the rim with day to day fluctuations of about 3 feet. The general condition of the floor of the pit, now about 65 feet down, has remained as last described a broad expanse with live flows filling the hollows, but two areas near the margins northeast and southwest have built up flat-topped slag heaps considerably above the general level of the pit floor. Latterly the vigor of flooding has decreased and smoke from solfataric areas has increased. The general tendency of the filling adjustments was to bring the levels of the floor margins to fair uniformity on Dec. 24 about 66 feet below the southeast station, but thereafter for three days, with average upbuilding of about 3 feet, the northeast slag heap pool built up 17 feet and the southwestern one 9 feet. This left the northeastern cone vent only 25 feet below the northeast rim of the pit, for the rim in that place is unusually low.

The measurements for the week were as follows:

Dec. 20, depression crag, 55 feet; lake, 86 feet; N. lake area, 79 feet.

Dec. 21, depression crag, 47 feet; lake,

80 feet; N. lake area, 79 feet; SW. pond, 76 feet.

Dec. 23, depression crag, 53 feet; lake, 74 feet.

Dec. 24, depression crag, 46 feet; lake, 72 feet; N. lake area, 70 feet; SW. pond, 69 feet.

Dec. 25, depression crag, 50 feet; lake, 72 feet.

Dec. 27, depression crag, 47 feet; lake, 74 feet; N. lake area, 64 feet; SW. pond, 67 feet.

The measurement for the seven days Dec. 21-27 indicates that the crag rose 8 feet, the lake 12 feet, the north lake area 5 feet, the southwest pond 9 feet, the northeast heap 20 feet and the southwest heap 19 feet. The net rise of the lava surface was thus about 12.15 feet or nearly like that of the lake, averaging 1.74 feet per day.

On Saturday, Dec. 21, 1918, at 4:30 p. m., activity of the spurting and flowing type with high gas pressure had been resumed, there was much puffing and hissing, while the fountains sprayed high at the east end of the lake and large dome grottoes had been built. At the north lake locality a big hissing dome stood, the east wall cones were flaming, the west floor cone ejected lava in spurts and at the base of the southwest wall of the pit a new pair of driblet cones was discovered. The central pond had reappeared, there was a fountaining vent south of the north cone and flows were moving everywhere on the floor surface with fronts alive and advancing.

About 5:30 p. m. a strong flow started to pour southward and westward from the northern fountaining vent and this was followed by heavy overflows northward and westward in pulsations from the central pond. The main lake surface showed eastward streaming.

On Dec. 22 flows continued to pour out, the northeast fill was developing a high flat plateau pool and the evening activity was dull.

On Monday, Dec. 23, at 4 p. m., the liquid flooding continued over the entire floor of Halemaumau, with the highest place apparently in the neighborhood of the southeast pond. It was becoming evident that the four lake centers of upwelling liquid east, north, southwest and in the middle of the pit were developing definite elevations with slopes away from the margins of the pools. The central crag was much more submerged, with a ring-shaped depression about its base. The surface streaming of the main lake was turbulent and mostly westward, but with some inrush to the southeast grotto. East and southwest of the lake there were somewhat raised lava pools with glowing edges and a recent flow had poured over the north lip of the lake. The northeast wall cone and a southwest pond vent were hissing strongly. The north lake heapings were steeper on their westward slope, the central pond had become a flat slag heap, the southwest pond occupied the top of a rampart ring with cones northeast of it, the west cone group was bulky and the southeastern cones were mere spatter spots. Lumpy irregularities in the floor extended from the north lake region northwestward.

From 10:30 a. m. until noon on Dec. 24 broad sheet flows were pouring out from the southwest pond and the west cone, while the high flat topped northeast pool, occupying the whole length of the former northeast valley, was putting out trickle flows around its margin. An area south of the main lake was tarnished with a mat of Pele's hair and appeared to be the surface most uplifted. The southwestern fill at the base of the wall was becoming high like the northeastern one so that there appeared to be a horseshoe of relatively high ground southwest, southeast and northeast.

The grotto domes of the main lake were less high, streaming was to the south and east and by noon the lake had sunk two feet within its basin. The eastern cones were hissing, the northeast vent had become a fountaining puddle source for the northeast pool, the solidified surface of which was now an elongate plateau falling off on all sides where trickle flows broke out along the edge, some of these being festooned streams. The surface of the pool was distinctly higher than the foot of the northeast wall of the pit and also stood above the level of the central floor.

The southern heaping of the north lake group had become a wide-angle

cone and the northern one was a steeper driblet construction showing on its west side a hinged lid which opened in spasms along a glowing gash.

The west cone was half buried, acting as source for flows pouring east and west, while the southwest pond bubbled at the base of a high eastern rampart and poured out torrents which swept to the foot of the wall of the pit and flooded the whole length of the former south valley as well as the central region surrounding the base of the central crag. The annular depression around the latter was filled up and the floods were gaining on the crag though it had risen somewhat. The southeast pond region was a smooth flat with one inactive crack showing spatter markings.

On Wednesday, Dec. 25, 1918, at 2:30 p. m., the flat plateau of fill southwest and northeast had become very marked, while the center was stationary. The liquid had been building around the southeastern horseshoe of the floor margin and a perpetual fountain was pumping up through the wall cone southwest, building a large spatter heap and oven and spouting inward toward the center of the pit. Quite symmetrically opposed to this the northeast cone was spouting and building up the northeast flat. The west cone appeared to be flowing beneath a crust and at 4 p. m. the southwest pond began to renew overflow. The southeastern vents fed live flows which were cascading into the main lake over the south bank of the lake and at 4 p. m. the lake itself overflowed its northwest margin. Seen from the northwest rim of Halemaumau this arrangement exhibited right and left symmetry in the development of broad flat topped tabular crusted pools over the sites of the former southwestern and northeastern wall valleys, while an intermediate plateau formed the highest part of the floor towards the southeast. Between these slaggy up buildings, with the main lake near the top, the central floor sloped downward to the northwest along the axis of symmetry. The cones southwest, east and north were hissing, the last named very noisily. The lake streamed irregularly but mostly southward with such striking increase of bubble fountaining that twenty or more small centers of ebullition could be counted at one time in addition to the grotto splashing.

The leaf shaped crusted pool forming the flat top of the northeast plateau was now becoming a truly remarkable feature of the pit. It had the aspect of an elongate delta developed from the northeast cone vent as a source extending fully 600 feet towards the northwest with steeply sloping margins somewhat like the slag heap built from the dump of a smelter. The method of building was illustrated about 3:45 p. m. by a sudden cracking up of the heavy crusts of the pool near the spouting vent. The crust suspended and sank, the spatter cone collapsed, the melt welled up flooding adjacent crust and breaking it down, and thus the cracking and foundering spread across the entire tabular area. When this process reached the margin there was voluminous overflow sending festooned streams down the slope but lasting only a few minutes. The process evidently manifested the mechanism whereby the tabular crust was repeatedly reformed as the liquid swelled beneath it. A distinct valley was developing between this plateau and the northeastern wall of the pit. In the course of the next twenty-four hours the process led to diminution in size of the upper flat surface, indicating inward building of the margins and probably decreasing supply at the source.

Live toes and glow cracks were seen all over the floor of the pit. Smoke had very greatly increased around the crag and the central pond depression, and a new smoke hole had opened at the northwest margin of the floor. Glowing cavernous crusts lay east of the main lake. After 4 p. m. the continuous flow at the southwest wall cone became spasmodic but the southwest pond next overflowed and sent sheet floods southward.

On Dec. 26 the flooding gradually diminished and on Friday, Dec. 27, at noon, both bench and lake magma were comparatively stationary, smoke had increased and there was sharp hissing from the cones. A driblet cone 6 feet high had formed at the central depression and at 11:45 a. m., this began suddenly to roar and spit out lava and the noise become continuous. The lake was

streaming to the west and north with some bubbling, the most violent bombardment being at an immense curtained grotto at its southwest end. The lake was now oval in form with thin blistering skins incessantly in motion, and its overhanging bank was about 3 feet high except during a slight noon rise. The southwest pond was crusted, quiet and 5 feet below its rim. The steeper north cone was split across its middle and glowed slightly. The smoke rose from the south and west sides of the crag, from the southeast pond site, from the west side of the lake, from the north heap and from the southwest pond.

The northeast pool vent was now two pots sluggishly heaving not more than 25 feet below the northeast edge of the pit. The flat upper surface of the pool was greatly raised and smaller, only about 200 feet long northwest-southeast, with driblet slopes away in all directions. Its plateau summit was oval.

A few flows trickled in the west central region but the intensive flooding had stopped. The floor was greatly heaped up along the base of the southwest wall of the pit all the way from the south station to the west station, and between this plateau and the northeastern one the triangular central region appeared low. In general there appeared to be a lull in the rising activity but the gas pressure continued strong.

For the fortnight ending at 8 p. m. Friday, Dec. 27, 1918, no local or distant earthquakes have been registered by the instruments of the Whitney Laboratory of Seismology. Spasms of tremor occurred as follows: Two spasms near 5 a. m., Dec. 15; others at 11:04 p. m. Dec. 16, after 1 p. m. Dec. 18, after 10 a. m. Dec. 20, and in the early morning of Dec. 23. Microseisms were moderate with temporary fluctuations until Dec. 23, when they became strong, as usual most so in the north-south azimuth, the waves decreasing to moderate after Dec. 25. Rhythmic microtremor was moderate Dec. 13-18, less Dec. 18-20, moderate with spasmodic fluctuation Dec. 20-25,, slight Dec. 25-26, strong Dec. 26-27 followed by decrease.

The movements of tilting were east and north Dec. 14-18, west and south Dec. 19-20, strong east and excessive north Dec. 21-24, and stationary with tendency southward Dec. 2527.

HAWAIIAN VOLCANO OBSERVATORY, Jan. 4, 1919.—During the New Year week ending Jan. 3, 1919, the central crag and lava lakes have subsided, the strongest downward movement beginning on Jan. 1. For the main lake the subsidence amounted to 6 feet per day after Jan. 1, though the average for the week was much less. The floor margin vents northeast and southwest have continued upward building by overflow so that the heaping of flow lava has greatly raised the floor level on these two sides, leaving the middle floor from the main lake to the northwest wall of the pit 20 to 30 feet lower. The flows from these marginal cracks dwindled during the week but there was revival of them at the southwest vent on Jan. 3. The general sequence of events since the solstice suggests that the main lava column reached its highest during the solstice week and that the release of pressure occasioned by the beginning of its subsidence generated liquid lava through the agency of gas effervescence. This liquid lava has bubbled up the wall crack and constructed slag heaps at the margins of the floor even while the central part of the lava column was sinking. The end of the week finds the pit showing all the signs of downward progress, spouting cones replaced by open inner pits containing pools of lava, great increase of smoke and sulphate stains at cracked areas, slumping of crusts recently swollen with foaming lava and slight falls of rock debris from the walls of the pit. The general floor level is about 60 feet below the rim and the liquid lakes are 20 feet lower.

Measurements for the week were as follows:

Dec. 27, depression crag, 47 feet; lake, 74 feet; NE. edge of floor, 50 feet; NW. edge of floor, 66 feet.

Jan. 3, depression crag, 52 feet; lake, 87 feet; NE. edge of floor, 36 feet; NW. edge of floor, 56 feet.

The central crag has thus subsided 5 feet in seven days, averaging .7 feet per day; the lake 13 feet, averaging 1.9 feet per day. The central floor near the

lake has been slightly built up by overflow, elsewhere it is slightly lower. The floor margin northeast has been built up 14 feet, averaging 2 feet per day, and on the northwest it has been built up 10 feet, averaging 1.4 feet per day. It thus appears that the main lake sank during the week by about the same vertical amount that the marginal vents have increased their heapings.

These measurements make a striking demonstration of the thermal complexity of the upper part of a lava column and show conclusively that we have to deal with no such simple relationships as those of a floating crust on a liquid substratum. In the short period of a week a projecting peak of bench magma sinks 5 feet. The liquid in a well beside it sinks 13 feet. The liquid spurting up wall cracks at the periphery of the lava column, with maximum temperature and pressure, builds up extensive flooded heapings 14 feet. The summit of these heapings was continuously flooding at a level over 50 feet above the liquid in the well, not 600 feet distant, and both enclosed in the same pit. There is no slightest question in this limited cylinder of all being parts of the same paste and it is perfectly evident that the marginal spurtings are not in hydrostatic equilibrium with the well lava. The whole system becomes explicable, only by recognizing that the reaction heat of escaping gases from solution in a stiff glassy magma below melts out vertical channels threading the paste wherever pressure is least. In the present case the pressure is least along the wall crack because the central pencil of lava is drawing downward and the marginal portions are sucking inward. The seeming paradox of subsidence inducing lava flows thus becomes quite intelligible and it is probable that the most violent manifestations of so-called "volcanic eruptions" are really produced by the beginnings of subsidence.

On Saturday, Dec. 28, 1918, at 7 p. m., there was strong increase of smoke and the lakes were depressed within their cups and flaring open pots had developed at the north lake heap, the central pond cone and the southeast pond crack. Northeast and southwest high glowing slag heaps were conspicuous while the wall cones east and southwest hissed continuously. The flaring of open ponds could be seen southwest and west. Small driblet flows pushed ahead steadily at the east end of the northeast slag heap and the north end of the southwestern heap. Flames were abundant, especially at the north and central pots. The northeast cone was sputtering and the eastern one flamed through a filagree orifice. The southern and central floors were dark. Streaming in the main lake was northward across its eastern half, southward in its western half, the currents dragging thin skins to the grottoes which emitted the deep rumble of interior fountains. There was a heavy stalactite curtain across the southwest grotto. The development of open pots by collapse was a new feature indicating a turning-point towards subsidence.

On Dec. 29 the pit was smoky and the glow moderate at night, showing some flaring from the north lake. In the evening the flaming had greatly diminished and the activity was dull.

On Dec. 30, at 3:30 p. m., the southeast pond showed an opening 15 feet across leading down to a much larger chamber with overhang all around and liquid lava 10 feet below the orifice, streaming westward to a fountaining cavern. The main lake was nearly brimming, surface streaming was first west, then east and afterwards there was slight sinking. A conical heap had developed between the northeast grotto of the main lake and the north lake locality. The north cone exhibited a continuous small jet of lava, the east and southwest cones were hissing mildly, smoke was abundant, concealing the south and southwest regions, there was some slight further encroachment of lava around the base of the central crag and fountains were splashing on the east side of the southwest pond. The northeast cone stood high at the summit of a slag heap close to the northeast wall and was flinging up a little lava spatter. The high western slag heap built against the wall now extended well around from the southwest to the northwest margin of the floor. Glow at night was dim and the smoke showed considerable fluctuation in amount.

On the evening of Tuesday, Dec. 31, flows continued to pour from the northeast vent and there was slight overflows from the main lake.

On Jan. 1, 1919, during the hour following noon the lava column appeared stationary, the lakes low, solfataric stains had developed at the vents and there was much Pele's hair to leeward of the lakes. The southeast pond pit was enlarged, the surface of the liquid 15 feet down and the streaming continued westward. The main lake margins were 10 feet high and the surface was stagnant. Open pits had developed at the north and west ponds and the southwest pond continued open. The central cone was still in place with a pot beside it and the crag peak appeared unchanged. A conical heap of crust with a depression beside it occupied the middle of the south floor. There was much smoke in the central and southwestern regions. A slightly sunken glowing pool had developed in the summit of the northeast slag heap and there was glow visible at the east end of the heap. The western heap was higher with smooth upper surface and the region extending northeastward from the main lake was now a valley between these two heaps.

On Jan. 2 at 6 p. m. the inner pit of the main lake was so deep above the liquid that the latter was barely visible from the southeast rim of the pit. The liquid was fully 20 feet below the floor level and the southeast pond appeared 30 feet below the rim of its pit. Heavy stalactites hung about both pools. The north lake now occupied a large pit covering the area of the former group of cones and made a bright flare at night. The central cone had a glowing pot beside it and the southwest pond was in an enlarged pit. There was some glow at the northeast cone and east of it. Fume had increased, general appearance indicated sinking and a small earthquake was felt at noon.

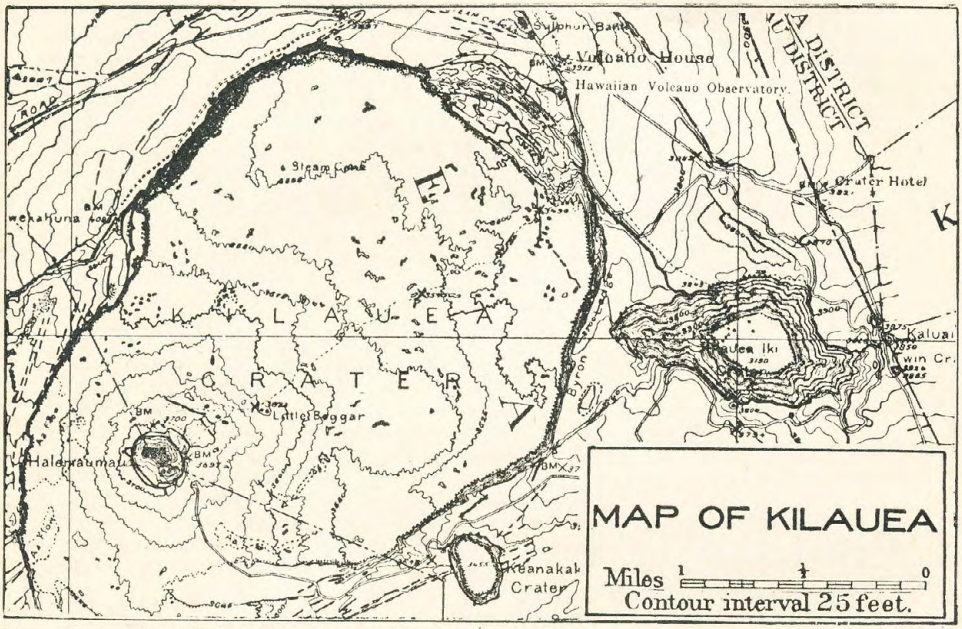
On Friday, Jan. 3, 1919, at 11 a. m., the south and southeast floors showed slumped crusts as though the inflating lava had poured out from beneath. These flows when last active had almost completely buried the southwest pinnacle of the central crag, though the summit peak of the crag still stood about 18 feet above the floor level at its base. There were fresh rock falls on the edge of the floor south, southsoutheast and north, and at 12:15 p. m. a pronounced avalanche fell from under the north station. There was much smoke from the ponds, from the north side of the crag and at the east cone locality. The southeast wall vent now a glowing crack with solfataric stain was hissing slightly. The lakes rose somewhat towards noon, the main lake standing 15 feet below the edge of its pit and the southeast pond 20 feet. The central cone was now replaced by a large glowing pot sending up a dense column of smoke. The floor sagged inward toward the southwest pond pit. Noises of surging, rumbling and splashing came from beneath the heavy stalactite curtains which hung around the orifice of the southeast pond pit and across the grotto entrances of the main lake. The streaming was eastward in the southeast pond and the main lake was covered with stagnant skin. The northeastern heap was now piled conically without flat top against the wall of the pit and was surrounded by two cones. Its summit stood only 15 feet below the low northeastern edge of the pit.

The southeast cone vent close to the wall of the pit had revived and two live flows poured north and south from it. The north lake had become an oval fountaining pool over 100 feet long in the north-south direction and the liquid streamed northward beneath walls only 5 feet high. There was continuous bubbling on the north side of this lake.

For the week ending at 8 p. m. Friday, June 3, 1919, there has been registered on the seismographs of the Whitney Laboratory a teleseism of considerable intensity at 4:40 p. m. Dec. 31, 1918, with center believed to be 4350 kilometers distant, possibly Fiji or Alaska. A weakly felt local quake occurred at 12:14 p. m. Jan. 2, the first for some weeks past. Microseisms were stronger about Dec. 30-31. Microtremor has been ordinary. The tilting was west and south Dec. 28-27, east and north Dec. 29-Jan. 1, west and south Jan. 2-3 and thereafter.

Very respectfully,

T. A. JAGGAR, JR.,
Director.



HAWAIIAN VOLCANO RESEARCH ASSOCIATION.

This society is a voluntary one, made up of subscribers to scientific work which is being executed by Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory, Volcano House, P. O., Hawaii. **All scientific exchanges should be sent to this address.**

In 1918 there were about 150 subscribers in Hawaii and elsewhere, firms and individuals. A group of firms and persons in Hilo built the main observatory building in the spring of 1912. The work was founded by the Massachusetts Institute of Technology. Publications to date have been weekly bulletins since the summer of 1911 now reprinted in Honolulu in monthly form. There are also special reports, printed from time to time.

The monthly bulletin is sent to regular annual subscribers to the work of the Association. L. A. Thurston is president of the Board of Directors of the Association, and L. T. Peck is treasurer. New subscribers who are interested in volcanoes will be welcomed in the Association. The Association aims: (1) To record volcanic activity and earthquakes in Hawaii; (2) to attract scientific men hither for special studies; (3) to promote the establishment of volcano observatories all over the world. The annual dues of regular members are $5; patrons of the Association subscribe larger amounts.

WHITNEY LABORATORY OF SEISMOLOGY.

The Whitney Laboratory of Seismology, named after an endowment fund for geophysical research held by the Massachusetts Institute of Technology, in memory of Caroline and Edward Whitney of Boston, is equipped with the following seismometric instruments rebuilt at the station in 1918 for the special needs of volcano research: two Bosch-Omori pendulums, high speed registration of local earthquakes; one optically recording seismograph for distant earthquakes; one clinograph registering E-W tilting of the ground. A vertical component seismograph was in December, 1918, set up in experimental operation. These are seated on concrete piers in a closed basement room having practically constant temperature, beneath the chief Observatory building near the hotel. Time is referred to a rated chronometer, checked at intervals by solar observations with a transit. Both instruments are loaned by the College of Hawaii. Hawaiian standard time (H. S. T.) is 10 hrs. 30 min. slower than Greenwich time.

CANCANI SCALE OF SEISMIC INTENSITY.

Expressed by accelerations measured in millimeters per second per second.

I.	Instrumental	0.0	2.5
II.	Very slight	2.5	5.0
III.	Slight	5.0	10.0
IV.	Sensible, mediocre	10.0	25.0
V.	Rather strong	25.0	50.0
VI.	Strong	50.0	100.0
VII.	Very strong	100.0	250.0
VIII.	Ruinous	250.0	500.0
IX.	Disastrous	500.0	1000.0
X.	Very disastrous	1000.0	2500.0
XI.	Catastrophic	2500.0	5000.0
XII.	Great catastrophe	5000.0	10000.0

Grade IV. is ordinarily the minimum perceived by the senses; and in grade XII. the acceleration, or rate of change of motion (jerk) reaches that of terrestrial gravitation.

In the standard form of report the maximum intensity or acceleration, designated by the symbol α, or max. α, is given in the conventional unit, the milligal. The milligal is a measure of acceleration, such that 1 milligal = 1/100 mm. per sec. per sec. = 10 μ per sec. per sec. The Cancani scale, here defined in terms of millimeters per sec. per sec., can therefore be expressed in milligals by multiplying each of the numbers by 100.